

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

This chapter presents the environmental consequences of restoration features of the LCA Plan on significant resources. Restoration opportunities that were initially considered, but were eliminated from further consideration and detailed analysis are described in Chapter 2. The following analysis compares the future without project conditions or the No Action Alternative to the following restoration opportunities: RO1 that was developed by considering restoration of critical deltaic processes; RO2 that was developed by considering restoration of geomorphic structures; and the TSP that was developed by considering all the sorting and critical needs criteria. These restoration opportunities are described in more detail in Chapter 2 Alternatives, and the Main Report.

A comparison of the direct, indirect, and cumulative impacts for each restoration opportunity and the TSP is presented. Direct impacts are those effects that are caused by the action and occur at the same time and place (section 1508.8(a) of 40 CFR Parts 1500-1508). For example: beneficial use of dredged material would directly create acres of marsh habitat or barrier island habitat. Indirect impacts are those effects that are caused by the action and are later in time or further removed in distance, but are still reasonably foreseeable (section 1508.8(b) of 40 CFR Parts 1500-1508). For example, diversions would indirectly result in land building and nourishment. Cumulative impacts are the effects on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from actions that individually are minor, but collectively result in significant actions taking place over time (section 1508.7 40 CFR Parts 1500-1508). For example, the incremental impacts of hydrologic restoration of at several localized areas could significantly modify an entire basin's hydrology. The cumulative impact analysis followed the 11-step process described in the 1997 report by the Council of Environmental Quality entitled Considering Cumulative Effects Under the National Environmental Policy Act.

This programmatic environmental analysis evaluates and compares these three alternatives from a qualitative perspective, commensurate with the conceptual level of detail within which these restoration opportunities were developed. Impact analysis described in this chapter is based on a combination of professional judgment and preliminary desktop modeling outputs for base, future-without conditions, and the three alternatives. Models are based on simplifying assumptions, subject to uncertainty and error, and are only approximations of real conditions. The models used in this study have not been fully validated.

4.1 SOILS

4.1.1 Future Without-Project Conditions - The No Action Alternative

Soil erosion and land loss would continue. Natural and man-made levees would continue to subside and organic soils would not be able to maintain their elevations due to subsidence, decreased plant productivity, and wave erosion. Delta formation would continue at the mouth of the Mississippi and Atchafalaya Rivers. As erosion continued, there would be a continued loss

in primary productivity due to loss of vegetated wetlands. Waterbodies would grow larger and wave erosion would accelerate causing further land loss, thus making coastal communities more vulnerable to tropical storms. In addition to land loss in coastal Louisiana, a large percentage of the Nation's wetlands would continue to disappear with accompanying impacts to wildlife, fisheries, coastal communities, and socio-economic resources.

4.1.2 Restoration Opportunities - Direct Impacts

Direct impacts to soil resources would primarily result from those project-related activities that would directly use, remove, or otherwise disturb soil resources. Direct adverse impacts to soil resources would primarily result from activities associated with construction of the various features of each plan.

RO1 (deltaic processes): Long-term significant positive impacts from dedicated dredging for marsh creation would result in some new land that would also be subject to consolidation, dewatering, and subsidence. Repairing eroding banks of the GIWW would also create new land. There would be short-term, minor-to-moderate adverse impacts associated with construction of restoration features.

RO2 (geomorphic structure): All restoration features in RO2, except for the MRGO restoration feature, would result in the direct impacts of creating marsh (dedicated dredging and beneficial use), gulf shorelines, or barrier shorelines. Stabilization of the gulf shoreline near Rockefeller Refuge and at Point Au Fer, maintaining the land bridge between Caillou Lake and the Gulf of Mexico, and barrier shoreline restoration would result in some new land, subject to consolidation, dewatering, and subsidence. There would be short-term minor-to-moderate adverse impacts associated with construction of restoration features.

TSP: Direct impacts would be a combination of both RO1 and RO2.

4.1.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to soil resources would primarily result from long-term and far field effects of freshwater and sediment diversions (reintroductions), which would create new lands, and nourish and protect existing wetlands. Salinity control structures would enhance bioaccumulation of organic material thereby helping to maintain and increase the organic soil resources. Marsh creation features would increase land area and form new wetland soil resources over time.

RO1 (deltaic processes): In the Deltaic Plain, there would be river diversions of freshwater, sediment, and nutrients that would build some new land, depending on the size of diversions and topography of the receiving area. River deposits would be subject to consolidation, dewatering, and subsidence. Vegetated wetlands would be enhanced by diversions of freshwater, sediment, and nutrients, which would increase plant productivity and vertical accretion of organic soils. Dedicated dredging for marsh creation would result in some new land that would also be subject to consolidation, dewatering, and subsidence. Hydrologic restoration would improve conditions for plant growth that would result in reduction of soil erosion and an increase in vertical accretion.

RO2 (geomorphic structure): Environmental restoration of the MRGO, shoreline restoration and stabilization, and maintaining the land bridge between Caillou Lake and Gulf of Mexico would improve conditions for plant growth, which would result in a reduction of soil erosion, and an increase in vertical accretion of organic soils. Marsh creation would increase organic soil resources, and vertical accretion of organic soils.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.1.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts comparison for RO1, RO2, and the TSP. Cumulative impacts to soil resources would primarily be related to the incremental impact of the proposed LCA Plan when added to all past, present, and future restoration efforts that have and would impact soils. With no action, a large percentage of the nation's wetland soils would continue to disappear with accompanying impacts to wildlife, fisheries, and coastal communities.

RO1 (deltaic processes): Cumulative impacts would be the net acres of wetland soils restored with RO1, compared to the nationwide coastal wetland loss acreage.

RO2 (geomorphic structure): Cumulative impacts would be the net acres of wetland soils restored with RO2, compared to the nationwide coastal wetland loss acreage.

TSP: Cumulative impacts would be the net acres of wetland soils restored with the TSP, compared to the nationwide coastal wetland loss acreage.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

Table 4-1
Comparison of Cumulative Impacts

*Includes Spatial/Geographic Extent (Continental United States [U.S.], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Soils	U.S. & SA: Natural processes of parent material, climate, organisms, relief, and time factors in soil formation.	U.S.: Formation of Soil Conservation Service later to become Natural Resources Conservation Service. SA: Louisiana coastal land loss of over 1.22 million acres within the last 70 years.	U.S. & SA: Continued erosion of soil resources. SA: Continued coastal land loss with desktop model prediction of nearly 328,000 acres of habitat loss over next 50 years.	U.S.: Continued technical assistance and cost-sharing programs for soil conservation to reduce soil losses. <i>RO1</i> : River diversions would build and/or nourish land; dedicated dredging would build new land; hydrologic restoration improves conditions for plant growth resulting in reduction of soil erosion. <i>RO2</i> : Marsh creation and barrier system restoration would build new land. <i>TSP</i> : Combination of both RO1 and RO2.
Offshore Sand Resources	U.S. & SA: Natural processes of erosion, tides, longshore transport, etc. build and deplete offshore sand deposits.	U.S. & SA: Natural and human activities build and deplete offshore sand deposits.	U.S. & SA: Continued natural and human activities build and deplete offshore sand deposits.	U.S.: Competition and multiple uses of offshore areas and sand resources (e.g., oil & gas exploration, and other restoration and construction projects). <i>RO1</i> : Cumulative impacts similar to future without-project conditions. <i>RO2</i> : Use of offshore sand resources for restoration would compete with other uses. Potential short-term moderate to significant adverse impacts to gulf water bottoms by removal of sand resources. All restoration features would have similar impacts. These impacts would be in comparison to nation-wide natural and human multiple use impacts to offshore sand resources. <i>TSP</i> : Similar to RO2.
Barrier Systems: Barrier Shorelines, Headlands, and Islands	U.S. & SA Barrier systems naturally build and erode dependent on deltaic cycle and other geomorphic processes. SA: Beginning with 1927 flood control of Mississippi River, and subsequent construction of jetties and other structures alters natural sediment availability and land building processes.	U.S.: Barrier systems continue building and eroding depending on human disruptions of natural geomorphic processes. SA: Disruption of Deltaic Cycle, thereby changing natural geomorphic processes of barrier systems resulting in net losses of all Louisiana coastal barrier systems in study area.	U.S.: Barrier systems continue building and eroding depending on human disruptions of natural geomorphic processes. SA: Continued disruption of deltaic cycle prevents rebuilding of barrier shorelines, headlands, and islands; eventual loss of many barrier islands and shoreline.	U.S.: Barrier systems continue building and eroding depending on human disruptions of natural geomorphic processes. <i>RO1</i> : No cumulative impacts. <i>RO2</i> : Long-term significant restoration of about 32 miles of barrier shorelines, compared to continued shoreline losses for the remaining 267 miles of Louisiana barrier systems. <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.

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** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Salinity Regimes	U.S.: Continued geomorphic and marine processes facilitate saltwater intrusion into upper estuaries. SA: Salinity regimes in subprovinces naturally fluctuate in response to deltaic cycle building and erosion phases.	U.S.: Continued geomorphic and marine processes would facilitate saltwater intrusion into upper estuaries. SA: Human disruption of deltaic cycle, navigation, and oil and gas channels leads to higher salinities and saltwater intrusion into interior of estuaries.	U.S.: Continued geomorphic and marine processes would facilitate saltwater intrusion into upper estuaries. SA: Continued human disruption of deltaic cycle; other geomorphic and marine process allow saltwater intrusion into upper estuaries; navigation and oil and gas channels would facilitate saltwater intrusion.	U.S.: Continued geomorphic and marine processes would facilitate saltwater intrusion into upper estuaries. <i>RO1</i> : Long-term minor-direct to long-term minor-to-moderate indirect impacts of localized freshening due to diversions could have cumulative impacts on wetlands types, plankton, benthic, and fish populations in adjacent coastal waters potentially changing species abundances, species compositions, and species distributions. <i>RO2</i> : Similar, but to a much lesser degree, <i>RO1</i> . <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of <i>RO1</i> and <i>RO2</i> .
Barrier Reefs	U.S. & SA: Natural processes form barrier reefs.	U.S. & SA: Barrier reefs endangered by pollution, and other human activities.	U.S. & SA: Continued ocean pollution and other human activities would lead to continued degradation of barrier reefs.	U.S.: Continued ocean pollution and other human activities would lead to continued degradation of shell reefs. <i>RO1</i> : Same as the future without-project conditions as this restoration opportunity does not include any barrier reef restoration features. <i>RO2</i> : Same as the future without-project conditions as this restoration opportunity does not include any barrier reef restoration features. <i>TSP</i> : Same as the future without-project conditions as this restoration opportunity does not include any barrier reef restoration features.
Total Vegetated Wetlands	U.S. & SA: Natural processes form vegetated wetland habitat.	U.S. & SA Deterioration and loss of total vegetated wetland habitat acreage.	U.S.: Continued loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in Nation.	U.S.: Implementing TSP would result in a small reduction to the rate of loss of vegetation habitat. <i>RO1</i> : Minor reduction in rate of loss of vegetation habitat and small increase in sustainability. <i>RO2</i> : Minor reduction in rate of loss of vegetation habitat and slight increase in sustainability. <i>TSP</i> : Small reduction in rate of loss of vegetated habitat and small increase in sustainability.

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Comparison of Cumulative Impacts**

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Fresh Marsh	U.S. & SA: Natural processes form fresh marsh.	U.S. & SA: Deterioration and loss of fresh marsh acreage through direct loss and transition to more salt-tolerant habitat types.	U.S.: Continued loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in Nation.	U.S.: Implementing the TSP would result in minor-to-significant reduction to rate of loss of fresh marsh <i>RO1</i> : Minor-to-significant reduction in rate of fresh marsh loss and small increase in sustainability. <i>RO2</i> : Minor reduction in rate of fresh marsh loss and slight increase in sustainability. <i>TSP</i> : Minor-to-significant reduction in rate of fresh marsh loss and small increase in sustainability.
Intermediate Marsh	U.S. & SA: Natural processes form intermediate marsh.	U.S. & SA: Deterioration and loss of intermediate marsh acreage through direct loss and transition to more salt-tolerant habitat types.	U.S.: Some loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in Nation.	U.S.: Implementing the TSP would result in minor-to-significant reduction to rate of loss of intermediate marsh. <i>RO1</i> : Minor-to-significant reduction in rate of intermediate marsh loss and minor-to-significant increase in sustainability. <i>RO2</i> : Minor-to-significant reduction in rate of intermediate marsh loss and minor-to-significant increase in sustainability. <i>TSP</i> : Minor-to-significant reduction in rate of intermediate marsh loss and small increase in sustainability.
Brackish Marsh	U.S. & SA: Natural processes form brackish marsh.	U.S. & SA: Conversion of fresher marshes to brackish marsh as coastal areas become exposed to higher salinities; but these land areas are now being subjected to land loss processes and conversion to more salt-tolerant habitat types.	U.S.: Some loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in Nation.	U.S.: Implementing the TSP would result in minor-to-significant reduction to rate of loss of brackish marsh. <i>RO1</i> : Minor-to-significant reduction in rate of brackish marsh loss and small increase in sustainability. <i>RO2</i> : Minor-to-significant reduction in rate of brackish marsh loss and slight increase in sustainability. <i>TSP</i> : Minor-to-significant reduction in rate of brackish marsh loss and small increase in sustainability.

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SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Saline Marsh	U.S. & SA: Natural processes form saline marsh.	U.S. & SA: Conversion of fresher marshes to saline marsh as coastal areas become exposed to higher salinities; but these land areas are now being increasingly subjected to land loss processes.	U.S.: Some loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in Nation.	U.S.: Implementing the TSP would result in small reduction to rate of loss of saline marsh. <i>RO1</i> : Minor reduction in rate of saline marsh loss and small increase in sustainability. <i>RO2</i> : Minor reduction in rate of saline marsh loss and small increase in sustainability. <i>TSP</i> : Small reduction in rate of saline marsh loss and small increase in sustainability.
Swamp - Wetland Forest	U.S. & SA: Natural processes form swamp-wetland forests.	U.S. & SA: Deterioration and loss of swamp-wetland forests.	U.S.: Some loss due to natural processes and development. SA: Accelerated coast wide loss. Most severe loss in nation.	U.S.: Implementing the TSP would result in minor reduction to current rate of loss of swamp-wetland forests. <i>RO1</i> : Small reduction in rate of swamp-wetland forest loss and small increase in sustainability <i>RO2</i> : Minor reduction in rate of swamp-wetland forest loss and slight increase in sustainability <i>TSP</i> : Small reduction in rate of swamp-wetland forest loss and slight increase in sustainability.
Barrier Shoreline Vegetation	U.S. & SA: Natural processes form barrier shoreline vegetation.	U.S. & SA: Deteriorating and loss of barrier shoreline vegetation.	U.S. & SA: Accelerated coast wide loss of barrier islands/shoreline vegetation.	U.S.: Implementing the TSP would result in slight reduction to accelerated rate of loss of barrier shoreline vegetation. <i>RO1</i> : Negligible reduction in rate of barrier shoreline vegetation loss. <i>RO2</i> : Minor reduction in rate of barrier shoreline vegetation loss and slight increase in sustainability. <i>TSP</i> : Minor reduction in rate of barrier shoreline vegetation loss and slight increase in sustainability.
Amphibians & Reptiles	U.S. & SA: Populations would respond to natural population-regulating mechanisms.	U.S. & SA: Decline in populations.	U.S. & SA: Continued decline in populations.	U.S.: Continued decline in populations. <i>RO1</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>RO2</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>TSP</i> : Increase the quantity and quality of available habitat types the greatest over the future without-project conditions.

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SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Mammals	U.S. & SA: Populations would respond to natural population-regulating mechanisms.	U.S. & SA: Decline in populations.	U.S. & SA: Continued decline in populations.	U.S.: Continued decline in populations. <i>RO1</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>RO2</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>TSP</i> : Increase the quantity and quality of available habitat types the greatest over the future without-project conditions.
Birds	U.S. & SA: Populations respond to natural population regulating mechanisms.	U.S. & SA: Decline in populations.	U.S. & SA: Continued decline in populations.	U.S.: Continued decline in populations. <i>RO1</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>RO2</i> : Increase the quantity and quality of available habitat types over the future without-project conditions. <i>TSP</i> : Increase the quantity and quality of available habitat types the greatest over the future without-project conditions.
Plankton	U.S. & SA: Populations respond to natural conditions.	U.S.: Populations respond to natural and human-induced perturbations. SA: Populations in interior and upper portions of subprovinces are becoming more saline-dominant species as landloss and saltwater intrusion into these interior regions continues.	U.S.: Populations would continue to respond to natural and human-induced perturbations. SA: Increased land loss and saltwater intrusion would lead to more saline-dominant populations.	U.S.: Populations would continue to respond to natural and human-induced (restoration projects) perturbations. <i>RO1</i> : In the Deltaic Plain, freshwater diversions result in localized species switching from saltwater-dominant to freshwater dominant. <i>RO2</i> : Restoration of geomorphic structure only would result in negligible impacts. <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.

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SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Benthic	U.S. & SA: Populations respond to natural conditions.	U.S.: Populations respond to natural and human-induced perturbations. SA: Populations in interior & upper portions of subprovinces are becoming more saline-dominant species as landloss and saltwater intrusion into these interior regions continues.	U.S.: Populations would continue to respond to natural and human-induced perturbations. SA: Increased land loss and saltwater intrusion would lead to more saline-dominant populations.	U.S.: Populations would continue to respond to natural and human-induced perturbations. <i>RO1</i> : In the Deltaic Plain, freshwater diversions result in localized species switching from saltwater-dominant to freshwater dominant. <i>RO2</i> : Short-term disturbance to sensitive benthic animals due to construction of restoration features. <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.
Fisheries Resources	U.S.: Fisheries habitat was reduced, while catch increased. SA: Reduction in sustainability of fisheries habitat, while access (marsh edge) increased; increased productivity and catch. Where freshwater flow was limited (particularly SP4) habitat building and access to estuarine environment was restricted.	U.S. & SA: Regulated catch; habitat loss decreased by coastal restoration efforts, continued net habitat loss. SA: Sustained to increasing populations.	U.S. & SA: Would have a net loss in fisheries population size and diversity.	U.S.: See TSP. <i>RO1</i> : Similar to the TSP below. <i>RO2</i> : Although this plan would help preserve some of the habitat and fishery productivity expected to be lost with no action within the LCA, it is unlikely that impacts would be measurable for the U.S. <i>TSP</i> : In the LCA, a long-term increase in fishery productivity would be expected and a shift in species composition from those generally more tolerant of higher salinities to those generally more tolerant of lower salinities. A decrease would be expected in production of species, such as brown shrimp and speckled trout, in areas most influenced by freshwater diversions (reintroductions). The U.S. would benefit by maintaining the productivity and diversity of marine fisheries.

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SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Essential Fish Habitat (EFH)	U.S. & SA: General decrease in quality and quantity of EFH.	U.S. & SA: Institutional recognition of decline in EFH (Magnuson-Stevens Fishery Conservation and Management Act). Coastal restoration aids some EFH.	U.S. & SA: Continued loss and degradation of EFH.	U.S.: See TSP. RO1: Maintain productive forms of EFH that would be lost in SA with no action, maintaining the ability of U.S. to support Federally managed species. There are no habitat areas of particular concern in the LCA study area. RO2: Maintain productive forms of EFH that would be lost in SA with no action, maintaining the ability of U.S. to support Federally managed species. There are no habitat areas of particular concern in the LCA study area. TSP: Maintain productive forms of EFH that would be lost in SA with no action, maintaining the ability of U.S. to support Federally managed species. There are no habitat areas of particular concern in the LCA study area.
Threatened & Endangered Species	U.S. & SA: General decrease in populations and critical habitat of was eventually institutionally recognized as threatened or endangered species and their critical habitat.	U.S. & SA: Institutional recognition of decline in threatened and endangered species (Endangered Species Act). SA: Loss of America's wetlands, portions of which provide critical habitat such as gulf shoreline, that are critical piping plover habitat.	U.S.: Institutional recognition of decline in threatened and endangered species (Endangered Species Act); continued National loss of wetlands. SA: Continued decline in populations and loss of critical habitat.	U.S.: Individual species restoration plans to maintain or increase populations and critical habitat. RO1: Generally increase and enhance all coastal wetland habitats. RO2: Increase and enhance piping plover critical habitat and would generally enhance all habitats. TSP: Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.
Flow and Water Levels	U.S. & SA: Increase in flow due to increase in precipitation. Increase in sea level.	U.S. & SA: Increase in flow due to increase in precipitation. Level is increasing. Rates increasing over historic.	U.S. & SA: Rates would continue to increase.	U.S.: Rates continue to increase. RO1: SP1-3, increased freshwater flow to study area. Decreased Mississippi River flow. Water level changes not known in coastal area. RO2: Similar to RO1, but to a lesser extent. TSP: Similar to RO1.

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SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Suspended Sediments	U.S.: Decrease due to reduction of erosion on land, reservoirs, and bank stabilization. SA: Sediment delivery by crevasses in SP1, SP2, and SP 3. Ended after 1928-flood control act.	U.S.: Decreasing due to reduction of erosion on land, reservoirs and bank stabilization. SA: Inflow of suspended sediments reduced in SP1-3; limited amount occurs through Atchafalaya River.	U.S.: Decreasing due to reduction of erosion on land, reservoirs, and bank stabilization. SA: Sediment supply does not offset land loss.	U.S.: Decreasing due to reduction of erosion on land, reservoirs, and bank stabilization. <i>RO1</i> : Increased sediment input. Decreased sediment transport in Mississippi below diversions. <i>RO2</i> : Similar to RO1, but to a lesser extent; sediment output decreases. <i>TSP</i> : Similar to RO1 and RO2, but greater; sediment input is increased, sediment output is decreased.
Water Use & Supply	U.S. & SA: Increased withdrawals of both surface and ground water in the coastal area have resulted from continued population and commercial growth.	U.S. & SA: Continued withdrawals. SA: Surface-water withdrawals are periodically reduced due to saltwater inundation in some areas	U.S. & SA: Continued withdrawals. SA: Some coastal areas, saltwater intrusion events continue & increase in frequency and magnitude. Result is reduced surface supplies & increased reliance on ground water, which is limited in many coastal areas.	U.S. Continued withdrawals. <i>RO1</i> : Less loss of fresh surface supplies compared to future with no action. Possible decrease of availability in Mississippi River. <i>RO2</i> : Negligible, if any, impacts. <i>TSP</i> : Similar to RO1.
Groundwater	U.S.: No direct impact to ground water. SA: No direct impact to ground water.	U.S. & SA: Continued withdrawals.	U.S. & SA: Continued withdrawals.	U.S: Continued withdrawals. <i>RO1</i> : No project-induced cumulative impacts expected. <i>RO2</i> : Similar to RO1. <i>TSP</i> : Similar to RO1.

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** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Water Quality	U.S. & SA: Degraded waterbodies due to untreated and uncontrolled discharges, especially in urbanized and/or industrialized areas.	U.S. & SA: Enactment of Federal and state legislation beginning in the 1970s to restore and protect waterbodies, especially with respect to point sources. Nonpoint sources still unregulated.	U.S. & SA: Continued Present Action. SA: Continued Present Action and increasing potential for accidental discharges due to exposed infrastructure because of coastal land loss.	U.S.: Continued Federal and state programs that require and/or encourage protection of waterbodies. <i>RO1</i> : Long-term minor-to-moderate positive/adverse effects of introducing river water from diversions into receiving basins; similar to what occurred naturally prior to construction of levees. Sediments introduced into the receiving basins from diversions or from direct placement (dredge material disposal) would add some constituents, but would likely not exceed alert levels or harm the environment. <i>RO2</i> : Sediments introduced into the receiving basins from diversions or from direct placement (dredge material disposal) would add some constituents, but would likely not exceed alert levels or harm the environment. <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.
Gulf Hypoxia	U.S. & SA: Extent of hypoxia likely less than current conditions.	U.S. & SA: Gulf hypoxia recognized as a National problem.	U.S.: Continued nutrient loading into Mississippi River, possible abatement. SA: Continued nutrient loading in the gulf, possible upstream abatement.	U.S.: Continued nutrient loading in Mississippi River with possible abatement. <i>RO1</i> : Small reduction in nutrients discharged into Gulf of Mexico. <i>RO2</i> : No effects. <i>TSP</i> : Similar to RO1.
Historic & Cultural Resources	U.S. & SA: Historic & cultural resources subjected to natural processes and man made actions	U.S. & SA: Institutional recognition via National Historic Preservation Act (and others). Human activities as well as natural processes can potentially destroy historic & natural resources	U.S. & SA: Potential loss of resources due to natural and human causes.	U.S.: In the long-term, arresting land loss would protect cultural resources from coastal erosion, etc. <i>RO1</i> : There is insufficient survey data of existing cultural resources in the proposed project areas and detailed project plans are unavailable. Cultural Resources surveys would be necessary. Required identification of resources prior to construction and restoration activities may provide some protection by preventing land loss. <i>RO2</i> : Same as RO1. <i>TSP</i> : Same as RO1.

**Table 4-1
Comparison of Cumulative Impacts**

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Recreation Resources	U.S. & SA: Not an issue.	U.S. & SA: Land loss causing dramatic changes in recreation opportunities.	U.S. & SA: Potential loss of recreational resource base due to coastal land loss.	U.S.: Slowing or reversing land loss and coastal erosion may protect recreation resources. <i>RO1</i> : Overall, RO1 would support and sustain a greater number of freshwater-based recreational opportunities, provide for a more stable freshwater-based recreation economy, and possibly increase the Louisiana recreation industry compared to the without-project conditions. <i>RO2</i> : Overall, RO2 would support and sustain a greater number of saltwater-based recreational opportunities, provide for a more stable saltwater-based recreation economy, and possibly increase the Louisiana recreation industry. <i>TSP</i> : Similar, but greater than, RO1 and RO2.
Aesthetics	U.S. & SA: Technical recognition via 1988 USACE Visual Resources Assessment Procedure. Institutional recognition via Wild and Scenic Rivers Act, Scenic Byways, and others. Visual resources have been destroyed, enhanced, or preserved by human activities.	U.S. & SA: Numerous scenic byways exist within the Louisiana Coastal Area. Visual Resource Assessment Procedure needed to determine other aesthetic resources that exist within the coastal area.	U.S. & SA: Continued human population growth and development and other human activities have the potential to destroy, enhance, or preserve visual resources.	U.S. & SA: Continued human population growth and development and other human activities have the potential to destroy, enhance, or preserve the quality of scenic byways and other undetermined visual resources. <i>RO1</i> : Cumulative impacts of maintaining visually appealing resources systems would further support tourism as one travels Louisiana's Scenic byways and remote areas of visual interest. <i>RO2</i> : Impacts similar to RO1. <i>TSP</i> : Impacts similar to RO1.
Air Quality	U.S. & SA: Not an issue.	U.S. & SA: Institutional recognition via Clean Air Act; deterioration of air quality due to increases in human populations and industry.	U.S. & SA: Continued deterioration of air quality despite legislative attempts to address.	U.S.: Continued deterioration of air quality despite legislative attempts to address. <i>RO1</i> : slight increase in vegetated wetlands aid in removal of carbon dioxide and other air pollutants; this would be in comparison to nation-wide natural and human-induced (restoration projects) impacts to air quality. Short-term minor adverse impacts due to construction of restoration features. <i>RO2</i> : Similar to RO1 except fewer restoration features would result in less absorption of air pollutants. <i>TSP</i> : Synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.

**Table 4-1
Comparison of Cumulative Impacts**

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Noise	U.S. & SA: Not an issue.	U.S. & SA: Institutional recognition-Noise Control Act of 1972 generally applicable only to areas of human development; although boats, airboats and other human activities may cause disturbances to fish and wildlife in remote regions of the study area.	U.S. & SA: Continued human population growth & development, recreation activities, industry, and other human activities typically have some noise pollution. Further institutional recognition likely to be enacted.	U.S.: Similar to future without-project conditions. <i>RO1</i> : Noise would typically only be associated with actual construction activities. All legal requirements for noise abatement would be followed. No significant cumulative impacts anticipated. These impacts would be in comparison to nation-wide natural and human-induced (restoration projects) noise impacts. <i>RO2</i> : Similar, but less than RO1, since RO2 has fewer restoration features. <i>TSP</i> : Impacts similar to RO1 and RO2.
HTRW	U.S. & SA: Not an issue.	U.S. & SA: Institutional recognition by USACE regulations for Phase 1 investigation.	U.S. & SA: Continued human population growth & development, industry, and other human activities would typically have some HTRW associated with them. Further institutional recognition would likely to be enacted.	U.S.: Continued human population growth and development, industry, and other human activities typically have some HTRW associated with them. Further institutional recognition likely to be enacted. <i>RO1</i> : Phase 1 investigations conducted on project-by-project basis; if necessary more intensive investigations performed. Potential HTRW would be avoided or removed. All plans would be investigated for HTRW. <i>RO2</i> : Same as RO1. <i>TSP</i> : Same as RO1.
Population	U.S. & SA: Not an issue.	U.S. & SA: Increased population in urban, suburban and rural coastal areas.	U.S. & SA: Increasing population in urban and suburban areas, retreating population in rural coastal areas.	U.S.: Increased population in urban and suburban areas <i>RO1</i> : Decrease in retreat of population from coastal areas. <i>RO2</i> : Impacts would be similar to RO1, but less due to fewer restoration features. <i>TSP</i> : Impacts would be similar to RO1 and RO2.
Infrastructure	U.S. & SA: Increasing infrastructure in the form of roads, bridges, pipelines, homes, and businesses.	U.S.: Heavy concentration of infrastructure. SA: Heavy concentration of infrastructure in several parts of the study area.	U.S.: Heavy concentration of infrastructure. SA: Increasing damage to infrastructure, reduced level of infrastructure development in areas nearest to coast.	U.S.: Heavy concentration of infrastructure. <i>RO1</i> : Reduced level of increases in infrastructure damages and long-term relocations. <i>RO2</i> : Impacts would be similar to RO1, but less due to fewer restoration features. <i>TSP</i> : Impacts would be similar to RO1 and RO2.

**Table 4-1
Comparison of Cumulative Impacts**

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Socio-Economic & Human Resources	U.S. & SA: Increased habitation, employment, and tourism.	U.S. & SA: Large population centers and employment and tourist activities.	U.S. & SA: Continued population growth with some population retreat in areas nearest to coast.	U.S.: Continued population growth and related resources. SA: Increased population in urban and suburban areas and decrease in coastal areas subject to increased flooding. Decrease in jobs in coastal area. <i>RO1</i> : Decrease in retreat of population and related jobs from coastal areas. <i>RO2</i> : Impacts would be similar to RO1, but less due to fewer restoration features. <i>TSP</i> : Impacts would be similar to RO1 and RO2.
Commercial Fisheries	U.S. & SA: Increases in fisheries industry, due to advancing technologies and increased fishing pressure.	U.S. & SA: Regulation of fishing maintains a billion dollar industry.	U.S.: Some decline expected as vulnerability of habitat increases. More regulation would be necessary to maintain a sustainable industry. SA: Severe decline as land loss continues.	U.S.: Decline expected as vulnerability of habitat increases. <i>RO1</i> : Industry would be more sustainable and less vulnerable. <i>RO2</i> : Impacts would be similar to RO1, but less due to fewer restoration features. <i>TSP</i> : Synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.
Oyster Leases	U.S.: Only major leasing program is in LA. SA: General increase in acreage leased, production limited by saltwater intrusion in areas with no freshwater introduction.	U.S.: Only major leasing program is in LA. SA: Leveling off of acreage leased, production limited by saltwater intrusion in areas with no freshwater introduction. Production limited in areas by mortality from over freshening by diversions.	U.S.: Only major leasing program is in LA. SA: Gradual loss of production from leases. Increased production in bands of intermediate distance from freshwater introduction.	U.S.: Only major leasing program is in LA. <i>RO1</i> : Gradual displacement of production to areas of intermediate distance from freshwater introduction. Possible overall decline due to over freshening of best reef habitat in Subprovince 1. <i>RO2</i> : Leveling off of acreage leased, production limited by saltwater intrusion in areas with no freshwater introduction. <i>TSP</i> : Gradual displacement of production to areas of intermediate distance from freshwater introduction. Possible overall decline due to over freshening of best reef habitat in Subprovince 1.

Table 4-1
Comparison of Cumulative Impacts

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Oil, Gas, & Mineral	U.S. & SA: Increasing development of refineries, wells, and other oil and gas producing facilities and equipment.	U.S. & SA: Large investment in refineries, wells, and other oil and gas producing facilities and equipment.	U.S. & SA: Increased damages to refineries, wells, and other oil and gas producing facilities and equipment; probable relocations of these assets.	U.S.: Same as future without-project conditions, except implementation of TSP would slightly reduce damages to oil and gas producing facilities and equipment; and reduced relocations of these assets (as compared to the without-project condition) RO1: Reduced damages to oil and gas producing facilities and equipment; and reduced relocations of these assets (as compared to the without project condition) RO2: Similar to RO1, but would also provide increased protection to the LOOP facility. TSP: Similar to RO1 and RO2.
Navigation	U.S. & SA: Increasing port facilities and inland waterways and traffic.	U.S. & SA: Large investment in port facilities and inland waterways and traffic.	U.S. & SA: Probable damages to and relocation of port facilities and inland waterways and traffic.	U.S. & SA: Greater investment in port facilities and inland waterways (as compared to the without-project condition). RO1: Increased dredging costs expected as a result of multiple diversions. RO2: Certain MRGO measures could cause long-run negative impacts to navigation traffic. TSP: Impacts expected to be similar to RO1 and RO2.
Flood Control	U.S. & SA: Construction of flood control levees, pump stations, and control structures.	U.S. & SA: Large investment in flood control levees, pump stations, and control structures.	U.S. & SA: Increased investment in flood control levees, pump stations, and other flood control facilities to prevent damage due to land loss.	U.S.: Reduced investment in flood control facilities (as compared to without-project conditions). RO1: Reduced investment in flood control facilities. RO2: Would have impacts similar to RO1. TSP: Would have impacts similar to RO1.
Pipelines	U.S. & SA: Development of extensive network of oil and gas pipelines.	U.S. & SA: Large investment in extensive network of oil and gas pipelines; increasing damages to and some relocation of these assets.	U.S. & SA: Increased damages and probable relocations of pipeline assets.	U.S.: Same as future without-project conditions, except implementation of the TSP would reduce losses of pipelines (as compared to future with no action). RO1: Reduced losses of pipelines. RO2: Similar to RO1. TSP: Similar to RO1 and RO2.

**Table 4-1
Comparison of Cumulative Impacts**

*Includes Spatial/Geographic Extent (Continental United States [U.S], and Study Area [SA], and Temporal (Past, Present, and Future Without-Project)

** Identifier Code: RO1 (deltaic processes); RO2 (geomorphic structure), and the TSP

SIGNIFICANT RESOURCE	Past Actions (Historic Conditions)	Present Action (Existing Conditions)	Future Without-Project The No Action Alternative	Cumulative Impacts (Comparison of Future With Proposed Action Impacts For each Restoration Opportunity and the TSP)
Hurricane Protection Levees	U.S. & SA: Construction of hurricane protection levees and pumping capacity.	U.S. & SA: Large investment in hurricane protection levees and pumping capacity.	U.S. & SA: Increasing investment in hurricane protection facilities to prevent damage due to land loss.	U.S.: Same as future without-project conditions, except implementation of the TSP would reduce losses of pipelines (as compared to future with no action). <i>RO1</i> : Reduced investment in hurricane protection facilities because levees would be more protected. <i>RO2</i> : Slight reduction of storm surge. <i>TSP</i> : Similar to RO1.
Agriculture	U.S. & SA: Not an Issue.	U.S. & SA: Institutional recognition. SA: Saltwater intrusion, especially in Chenier Plain problem for rice farmers.	U.S.: Continued institutional recognition. SA: Continued coastal land loss and saltwater intrusion reduces opportunities for agriculture.	U.S.: Continued institutional recognition. <i>RO1</i> : Reduced damages to coastal agricultural areas. <i>RO2</i> : Similar to RO1. <i>TSP</i> : Similar to RO1.
Forestry	U.S. & SA: Not an Issue.	U.S.: Institutional recognition via regulations on forest harvest practices. SA: Institutional regulation of forest harvest practices. Continued coast wide forest deterioration, especially swamp and wetland forests.	U.S.: Continued institutional recognition; however, increasing human populations result in continued loss of forested areas and reduces forestry opportunities. SA: Continued coastal land loss reduces forestry opportunities.	U.S.: Continued institutional recognition; increasing human population growth and continued demand for diminishing forestry resources and reduced forestry opportunities. <i>RO1</i> : Net decrease in forestry resources; however, increase in swamp and wetland forests. <i>RO2</i> : No cumulative impacts. <i>TSP</i> : Similar to RO1.
Water Supply	U.S. & SA: Not an issue.	U.S. & SA: Institutional recognition (Clean Water Act and others); saltwater intrusion into historically fresh water areas; industrial pollution of waters; changes to hydrology by levees affect water supply to wetlands.	U.S. & SA: Continued institutional recognition; continued saltwater intrusion; continued industrial pollution; continued changes to hydrology that affect water supply to wetlands.	U.S.: Continued institutional recognition; continued saltwater intrusion; continued industrial pollution; continued changes to hydrology that affect water supply to wetlands. <i>RO1</i> : Lower salinities in some areas positively affecting industry, agriculture, and the public supply. <i>RO2</i> : Reduction in saltwater intrusion in the MRGO area. <i>TSP</i> : Similar to RO1.

4.2 OFFSHORE SAND RESOURCES

4.2.1 Future Without-Project Conditions - The No Action Alternative

Under the future without-project condition, large areas of the offshore sand shoals and nearshore sand bodies would likely continue to remain largely undisturbed from sand mining activities for coastal restoration. The distances involved, especially for removal of sands from the major offshore shoals, are generally considered too great to be cost effective for use in any but the largest coastal restoration activities. These areas would continue to be impacted by oil and gas exploration and extraction, and possible use of sands for construction of hurricane and flood control levees, and mineral exploration activities.

4.2.2 Restoration Opportunities - Direct Impacts

Direct impacts to offshore sand resources would primarily result from those project-related activities that would directly use, remove, or otherwise disturb them. Direct adverse impacts to offshore sand resources would primarily result from sand harvesting/mining (e.g., dredging) activities associated with obtaining sediments (sands) for construction/restoration of the various features of each plan.

RO1 (deltaic processes): RO1 does not present any likely restoration opportunities for use of offshore sand resources; hence, there would be no direct impacts.

RO2 (geomorphic structure): Almost all of RO2 restoration features could potentially impact offshore sand resources including: restoration of the Barataria Basin barrier shoreline at the Caminada Headland and Shell Island; Terrebonne Basin barrier shoreline restoration at Isles Dernieres, and East Timbalier; Gulf stabilization at Point Au Fer Island; restoration of the northern shore of East Cote Blanche Bay at Point Marone; restoration of the land bridge between Caillou Lake and the Gulf of Mexico; and stabilization of the gulf shoreline at Rockefeller Refuge.

Offshore sand resources could potentially be used for restoration of barrier systems (barrier shorelines, headlands, and islands) in Subprovinces 2 and 3. For Subprovince 2, preliminary estimates of about 21,290,000 cubic yards (cy) of sand would be required for the first lift in restoring the Caminada-Moreau Headland and Shell Island reaches in the Bayou Lafourche and Plaquemines barrier systems. For Subprovince 3, about 28,091,000 cy of sand would be required to restore most of the Isles Dernieres barrier system, and about 11,719,000 cy of sand would be required to restore the East Timbalier Island. Hence, a total of about 61,100,000 cy of sand could potentially be required for the first lift for barrier shoreline, headlands, and island restoration actions. Sand resources could also be used as an alternative to, and/or in addition to, hardened structures proposed for gulf shoreline stabilization in Subprovinces 3 and 4.

Uses of offshore sediments would require a project-by-project analysis of potential environmental impacts of the borrow sites. Use of offshore sand sources, such as Ship Shoal, in Federal waters would require coordination with the Mineral Management Service (MMS) for appropriate permits to use this resource. The District is presently coordinating with the MMS

with regard to utilizing Ship Shoal as a potential source of sands for restoration of the Barataria barrier islands. In addition, the District, along with other Federal and state natural resource agencies, is a participating member of the MMS Louisiana Offshore Sands Task Force that is presently determining strategies for multiple uses of sands and other resources under jurisdiction of the MMS.

Removal of the large volumes of sand resources (about 61,100,000 cy) for restoration of barrier systems in Subprovinces 2 and 3 would result in the following long-term and short-term moderate adverse direct impacts:

- sand resources would be unavailable for other uses;
- removal (dredging) of offshore sand resources would destroy existing benthic community systems within the areas where sands are removed;
- potential for cultural or historic relics to be disturbed or lost during dredging operations;
- potential for disturbing oil and gas infrastructure (pipelines & rigs);
- removal (dredging) of offshore sand resources would alter gulf bottom topography; and
- removal of offshore sand resources would cause short-term turbidity and low dissolved oxygen conditions, but these conditions would return to ambient following dredge removal operations.

TSP: The TSP would have direct impacts similar to, but somewhat less than RO2.

4.2.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to offshore sand resources would primarily result from long-term and short-term adverse effects of disturbances to offshore sand sites during removal of sand sediments for construction of restoration opportunities.

RO1 (deltaic processes): RO1 does not present any likely restoration opportunities for use of offshore sand resources. Hence, the indirect impacts would be similar to the future-without project conditions.

RO2 (geomorphic structure): Removal of the large volumes of sand resources that would be required for coastal restoration of barrier systems would indirectly have the following long-term and short-term adverse indirect impacts:

- marine organisms that utilize the gulf bottom substrates (especially benthos) would have to adapt to changes in gulf bottom topography;
- alteration of gulf water bottoms may change wave dynamics, thereby potentially changing onshore storm-wave impacts, leading to greater shoreline erosion;
- potential disruption of commercial and recreational fishing; and
- alteration of gulf water bottoms may change littoral drift dynamics.

TSP: The TSP would have indirect impacts similar to RO2.

4.2.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to sand resources would primarily be related to the incremental impact of all past, present, and future sand resource harvesting/mining activities.

RO1 (deltaic processes): RO1 does not present any likely restoration opportunities for use of offshore sand resources; hence, there would be no cumulative impacts.

RO2 (geomorphic structure): The long-term and short-term adverse cumulative impacts of RO2 would principally be related to the competition for multiple uses of sand resources removed or otherwise impacted from offshore sand sources. In addition to estimates of about 61,100,000 cy of sand that would be required for restoring the barrier systems of Subprovinces 2 and 3, other restoration activities, as well as other construction activities requiring sand fill would be competing for offshore sand resources and would impact these resources. Generally, potential cumulative impacts and competing uses of offshore sand resources include:

- Offshore sand resources provide substrate and habitat for aquatic marine organisms that would be altered and/or lost during dredging operations to remove sand resources. The potential loss of about 61,100,000 cy of sand and the disruption of gulf bottoms by extraction (dredging) of this sand for LCA restoration efforts would be in addition to any other similar extraction activities of offshore sand resources.
- Offshore sand resources contain or cover other natural resources such as minerals, oil, and gas deposits. Extraction of this sand resource for LCA restoration efforts would disrupt, in the short-term, any other multiple use activities such as exploration or extraction activities by oil, gas, and mineral operations.
- The large volumes of sand required for LCA restoration efforts would significantly alter gulf bottoms over approximately 5,000 to 10,000 acres. This would be in addition to other actions that would alter the gulf bottoms.
- The removal of such large volumes of offshore sands (about 61,100,000 cy) over hundreds, if not, thousands of acres of gulf bottoms could potentially alter wave dynamics that may increase the already high rates of shoreline erosion of nearby barrier shorelines, headlands, and islands.

TSP: Cumulative impacts of the TSP would be a synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.3 SALINITY REGIMES

4.3.1 Future Without-Project Conditions - The No Action Alternative

Figures 4-1 through **4-4** display modeling results for salinity patterns under the base conditions and future without-project conditions for each subprovince. Models are based on simplifying assumptions, subject to uncertainty and error, and are only approximations of real conditions. The models used in this study have not been fully validated and their results should be considered within that context. Appendix C, "Hydrodynamic and Ecological Modeling" of the Main Report provides a more detailed presentation of the numerical model results of salinity distributions. These models are static images (snapshots) of typical salinity distributions.

The future without-project mean salinity distributions for Subprovince 1 are displayed in **figure 4-1**. The freshest mean salinities, 0-2 parts per thousand (ppt), would be found in the interior-most portions of the subprovince in the vicinity of Lake Maurepas (boxes IA and IB) and in the general vicinity south of the Mississippi River Gulf Outlet (MRGO) and Caernarvon (boxes VA and VB). Lake Pontchartrain would grade from 2-4 ppt in the eastern portions to 4-6 ppt in the western portions of the lake. The southern portions of the Lake Borgne area (box IIIA) would have a mean salinity range of 6-8 ppt with the northern portions of the lake ranging from 8-10 ppt (box IIIB). The eastern portion of the Mississippi River Delta (box VE) would have mean salinity range of 2-4 ppt. The remainder of the subprovince, Chandeleur Sound and Breton Sound (boxes IV, VC, and VD), would have the greatest mean salinity ranges of greater than 10 ppt.

The future without-project mean salinity distributions for Subprovince 2 are displayed in **figure 4-2**. The hydrologic model assumed that the Davis Pond Diversion would be running all year at 5,000 cfs. At the present time, such an operation scheme is not authorized. The interior-most portions of the subprovince (boxes 1A, 1B, 2A, 2B, 3A, and 3B) would have the freshest mean salinity range of 0-2 ppt. The region east of the Barataria Bay Waterway and extending from Myrtle Grove, south to the western portion of the Mississippi River Delta (box 4B) would have a mean salinity range of 4-6 ppt. The Caminada Bay and headland area (box 4A) would have the highest mean salinity range of greater than 10 ppt.

The future without-project mean salinity distributions for Subprovince 3 are displayed in **figure 4-3**. The freshest portions of the subprovince would be the interior portions of Terrebonne Parish (box I) with a mean salinity range of 0-2 ppt. The areas adjacent to the Atchafalaya River, Wax Lake Delta, and regions surrounding East and West Cote Blanche Bays would have a mean salinity range of 2-4 ppt (boxes IV, VIII, and IX). The area extending from Caillou Lake in the east to Point au Fer in the west (box V) and the area surrounding Vermilion Bay (box VII) would have a mean salinity distribution of 4-6 ppt. The interior portion of Terrebonne Bay (box II) would have a mean salinity distribution of 6-8 ppt. The area from Terrebonne Bay in the east to Caillou Bay in the west (boxes III and VI) would have the highest mean salinity range of greater than 10 ppt.

The future without-project mean salinity distributions for Subprovince 4 are displayed in **figure 4-4**. The interior regions of the subprovince, extending from Freshwater Bayou in the

eastern portion of the subprovince, north of Louisiana State Highway 82, and west of Grand Lake (boxes 2C1, 2C2, 2A1, 2B1, 2B2, 2A2, 2A4, 2A3, and 3E5) and the isolated areas west of Calcasieu Lake (boxes 3E6, 301, 306, and 3C2) would have the lowest mean salinity range from 0-2 ppt. The area south of White Lake (boxes 1C2 and 1B2), east of Calcasieu Lake (box 3E4), bordering the Sabine River (boxes 3B1, 3B2, 3B3, and 3B4) and bordering the western gulf shoreline (box 3A2) would have a mean salinity range of 4-6 ppt. The areas bordering the gulf shoreline from Freshwater Bayou, west to Lower Mud Lake (boxes 1B3, 1B1, and 1A1), and the area west of Calcasieu Lake (boxes 3C1, 3C4, and 3C5) would have a mean salinity range of 6-8 ppt. The area at the mouth of the Sabine River (box 3A1) and west of Calcasieu Lake (boxes 3D2 and 3D3) would have a mean salinity range of 8-10 ppt. The Calcasieu Lake and immediate surrounding area (boxes 3E1, 3E2, 3E4, and 3D4) would have the greatest mean salinity range of greater than 10 ppt.

Without action, salinity regimes would continue to be impacted by riverine and marine influences that have shaped their present patterns as well as other natural and human factors such as: sea level change, navigation channels, and oil and gas canals resulting in continued coastal habitat loss in both the Deltaic and Chenier Plains. Land building would continue in the Deltaic Plain at the two active deltas, as well as in areas influenced by CWPPRA projects and the Davis Pond and Caernarvon Freshwater Diversion Projects. Coastal habitats in these areas of land creation would primarily be freshwater marsh, a result of the riverine influence that formed them. Other areas in the Deltaic and Chenier Plains would experience habitat switching from freshwater marsh and bottomland hardwood forest, including cypress/tupelo swamp, to intermediate, brackish, and saline marshes as salinity regimes adjust with increased saltwater intrusion and marine influence.

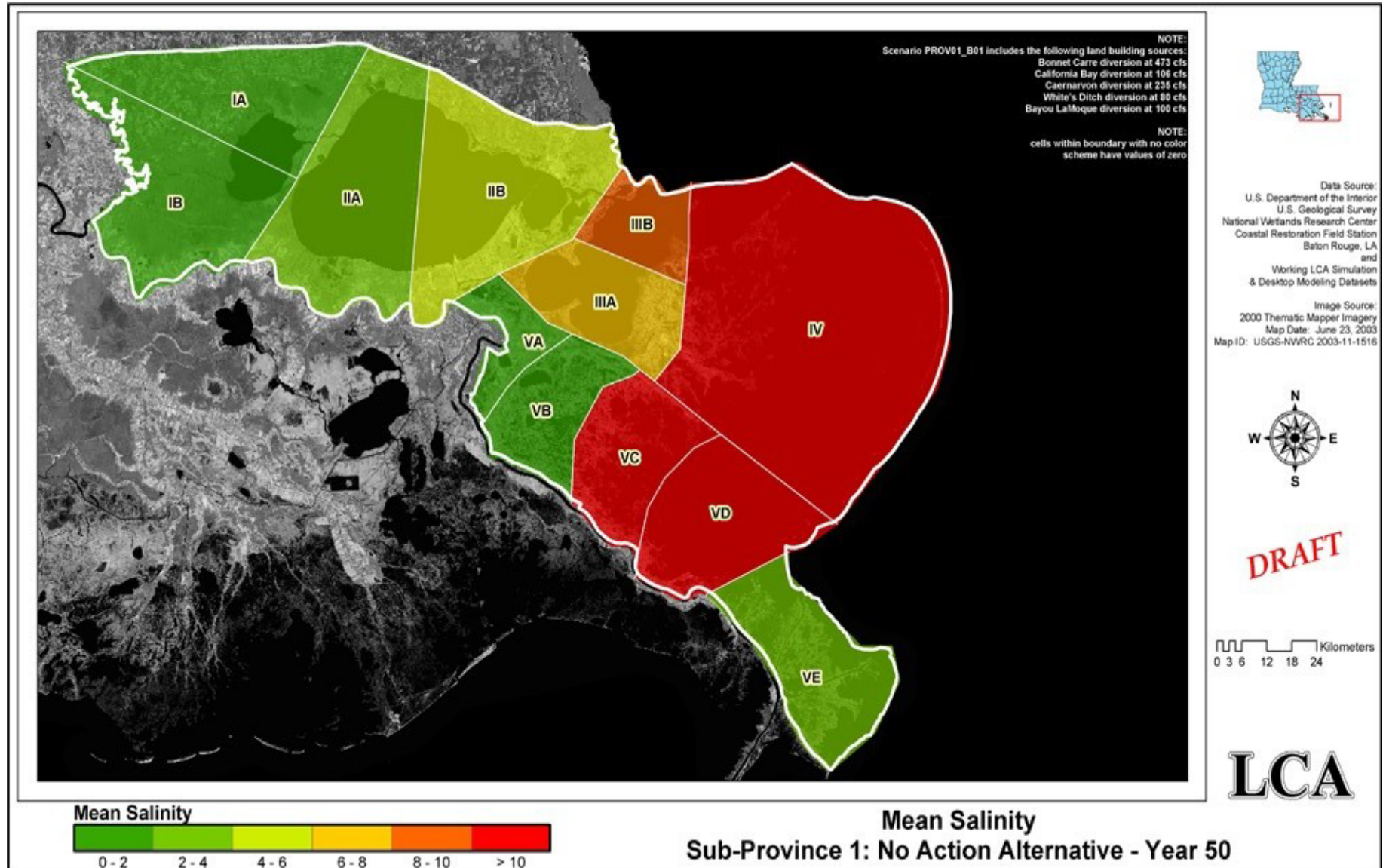


Figure 4-1. Modeling outputs displaying mean salinity under base and future without-project conditions in Subprovince 1.

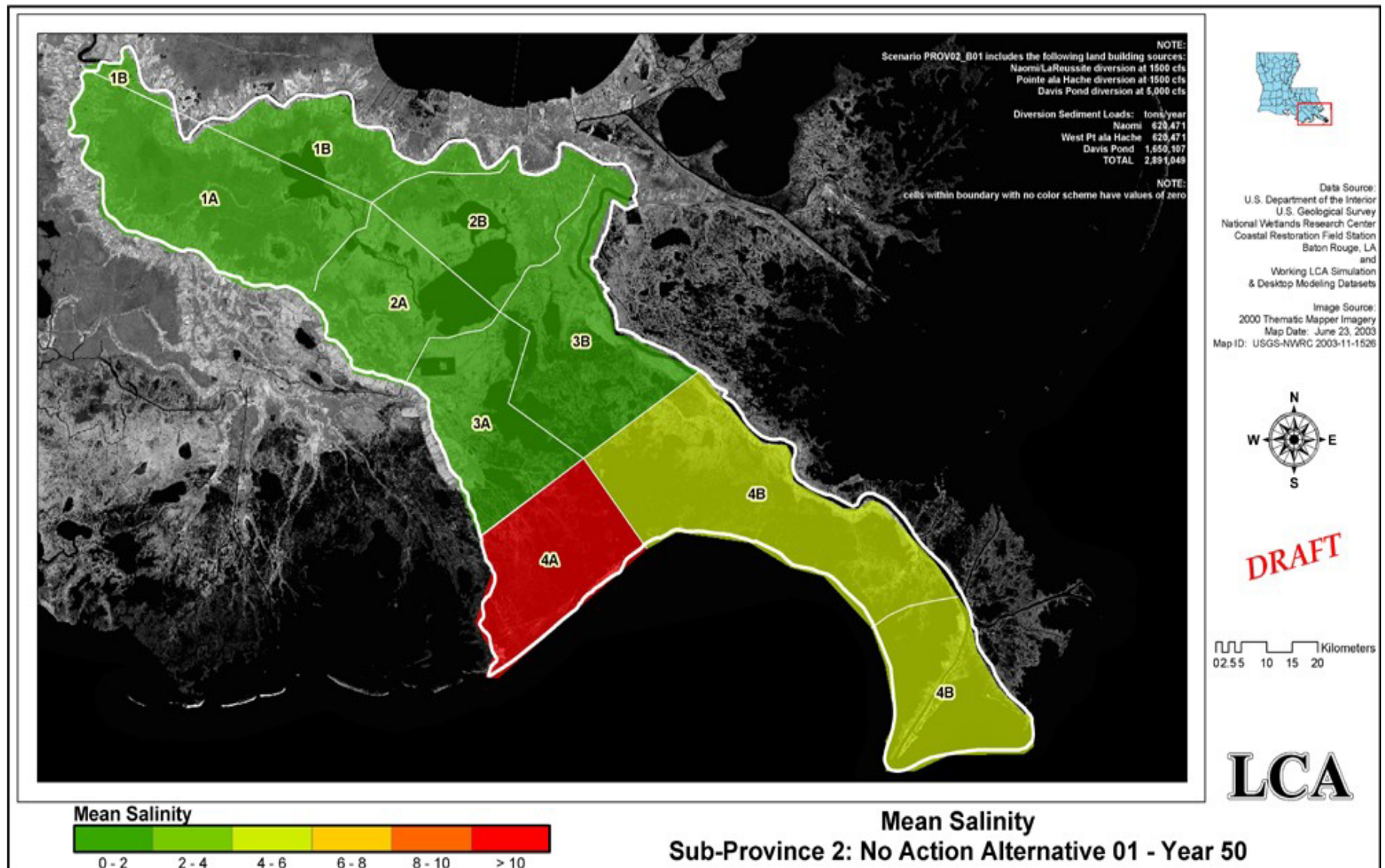


Figure 4-2. Modeling outputs displaying mean salinity under base and future without-project conditions in Subprovince 2.

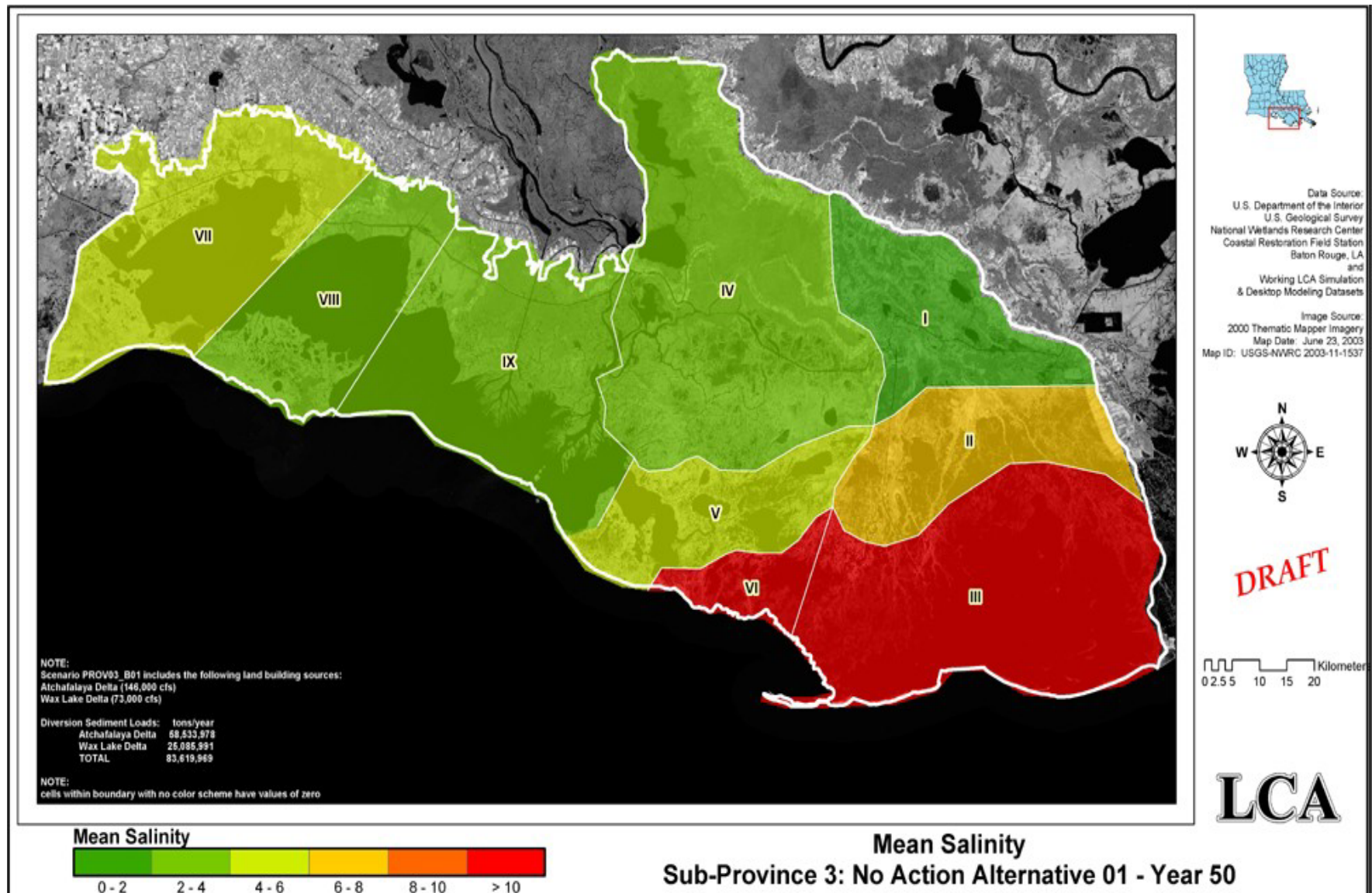


Figure 4-3. Modeling outputs displaying mean salinity under base and future without-project conditions in Subprovince 3.

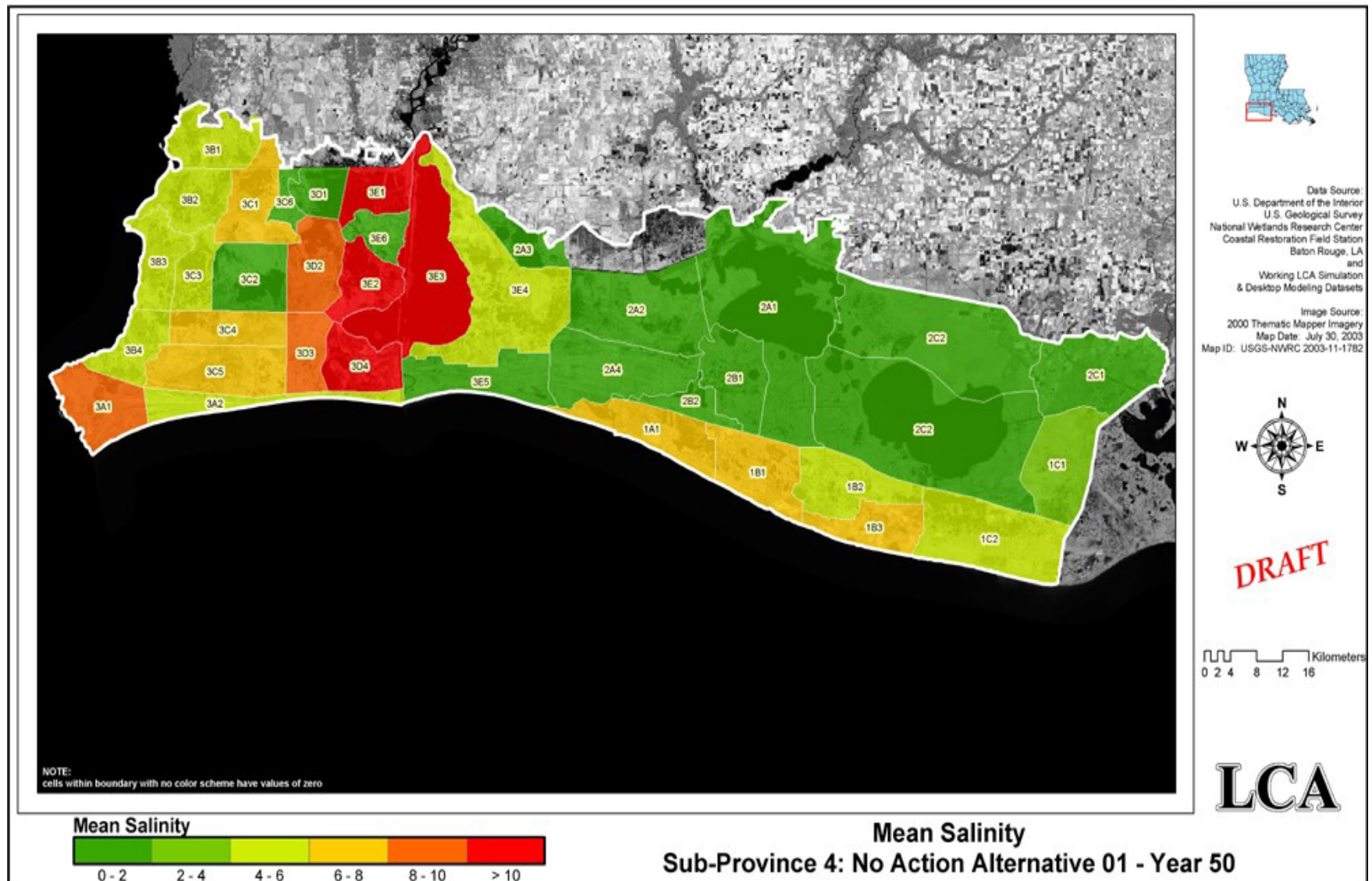


Figure 4-4. Modeling outputs displaying mean salinity under base and future without-project conditions in Subprovince 4.

4.3.2 Restoration Opportunities - Direct Impacts

Restoration opportunity-induced impacts to salinity regimes were determined by the interagency, interdisciplinary PDT utilizing the preliminary hydrodynamic modeling efforts for the baseline, future without-project conditions, salinity comparisons of the final array of coast wide plans, and best professional judgment. **Table 4-2** displays the salinity regime impacts by subprovince.

Table 4-2. Salinity Regimes Impacts

Subprovince	RO1 (deltaic processes)	RO2 (geomorphic processes)	TSP
Subprovince 1	The salinity regime would be similar to the future without-project conditions except salinities would slightly freshen the Lake Borgne area and the northern portions of Breton Sound.	Similar to future without-project conditions.	Similar to RO1.
Subprovince 2	The salinity regime would be similar to the future without-project conditions except salinities would slightly freshen the Caminada Bay and nearby headland areas.	Similar to future without-project conditions.	Similar to RO1.
Subprovince 3	Salinity regime would be similar to the future without-project conditions except salinities would slightly freshen the upper reaches of Terrebonne and Timbalier Bays.	Similar to future without-project conditions.	Similar to RO1.
Subprovince 4	Similar to future without-project conditions.	Similar to future without-project conditions.	Similar to future without-project conditions.

RO1 (deltaic processes): The direct impacts of RO1 on salinity regimes would be similar to the future without-project conditions except for slight freshening in some areas. The most significant freshening would occur in Lake Borgne, the northern part of Breton Sound, Caminada Bay and the nearby headland areas, and upper reaches of the Terrebonne and Timbalier Bays, and the marshes directly north of these bays (see **table 4-2**).

RO2 (geomorphic structure): The direct impacts would be similar to the future without-project conditions (see **table 4-2**).

TSP: The direct impacts would be similar to those described for RO1 except that implementation of some of the geomorphic features would have a minor localized affect on the salinity regime in some specific areas (see **table 4-2**).

4.3.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to salinity regimes would primarily result from long-term and far field effects of diversions (reintroductions) and salinity control structures.

RO1 (deltaic processes): The long-term minor-to-moderate indirect impacts include the following:

- Increased volumes of fresh water from diversions may impact the receiving basin and the distribution of salinity regimes throughout the receiving basin. The medium sized diversions would have a greater impact than the smaller diversions.
- Marsh creation/restoration and increased volumes of fresh water from diversions may possibly lead to short-term stratification, principally in deeper areas of the receiving basin. The medium sized diversions would have a greater affect than the smaller diversions.
- Marsh creation/restoration and increased volumes of fresh water from diversions may have a minor impact on the tidal prism. This would have a minor indirect impact on tidal flows and the salinity regime. The medium sized diversions would have a greater impact than the smaller diversions.
- Marsh creation/restoration and increased volumes of fresh water from diversions may impact receiving basin mixing patterns. This would have a minor indirect impact on the tidal prism and tidal flows with subsequent minor impacts on the salinity regime. The medium sized diversions would have a greater impact than the smaller diversions.
- Marsh creation/restoration and increased volumes of fresh water from diversions may impact sheet flows and channel flows in the receiving basin that would indirectly impact salinity regimes. The medium sized diversions would have a greater impact than the smaller diversions.
- Diversions of colder river waters with a typical monthly average temperature differential of about 5°C to 8°C between the river and receiving area waters may change marsh temperature distributions. This could change the circulation patterns and density gradients (Day et al., 1989) thereby potentially impacting the salinity regime. The medium sized diversions would have a greater impact than the smaller diversions.

RO2 (geomorphic structure): Impacts would be similar to the future without-project conditions. However, additional long-term, minor, indirect impacts include the following:

- Marsh creation/restoration and barrier shoreline/island restoration with attendant closure of numerous existing small passes may impact the distribution of salinity regimes throughout the basin.
- Marsh creation/restoration and barrier shoreline/island restoration with attendant closure of numerous existing small passes may have a minor impact on the tidal prism. This would have a minor indirect impact on tidal flows and the salinity regime.
- Marsh creation/restoration and barrier shoreline/island restoration with attendant closure of numerous existing small passes may impact receiving basin mixing patterns. This would have a minor indirect impact on the tidal prism and tidal flows with subsequent minor impacts on the salinity regime.

- Marsh creation/restoration and barrier shoreline/island restoration with attendant closure of numerous existing small passes may have a minor impact on sheet flows and channel flows in the receiving basin. This would have a minor indirect impact on salinity regimes.

TSP: The long-term minor-to-moderate indirect impacts would be similar to those described for RO1 and RO2.

4.3.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to salinity regimes would primarily be related to the incremental impact of all past, present and future salinity-altering activities.

RO1 (deltaic processes): The long-term minor direct and minor-to-moderate indirect impacts to salinity regimes described above are compared and contrasted to instances of natural and human-induced changes to salinity regimes in adjacent gulf coast states as well as coastal states nationwide. In addition, direct and indirect impacts to salinity distributions would also impact other significant resources, especially living resources, in the receiving basins. For example, introduction of fresh river water into estuarine systems could have dramatic short-term impacts on plankton, benthic, and fish populations in adjacent coastal waters. Introduction of fresh river water flows from proposed diversions (reintroductions) would be expected to change species abundances, species compositions, and species distributions. Such cumulative impacts to other significant resources are also described in more detail under each specific significant resource.

RO2 (geomorphic structure): Cumulative impacts would be similar to RO1, but to a lesser degree. Restoration features would include barrier shoreline/island restoration with attendant closure of existing small passes, but would not introduce any additional fresh water into the study area.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.4 BARRIER SYSTEMS: BARRIER SHORELINES, HEADLANDS AND ISLANDS

4.4.1 Future Without-Project Conditions - The No Action Alternative

The natural and human-induced land-loss processes on these barrier systems would likely continue at the present rates. Marine influences and tropical storm events would be the primary factors affecting land loss of the barrier island systems. As this land loss trend continues, hydrologic connections between the gulf and interior areas would increase and exacerbate land loss and conversion of habitat type within the interior wetland communities.

With no action the following resources would continue to diminish: critical habitats for threatened and endangered species such as the piping plover, sea turtles, and brown pelican; essential and diverse habitats for migratory birds and other wildlife; essential spawning, nursery, nesting, and feeding habitats for commercially and recreationally important species of finfish and shellfish, as well as other aquatic organisms. The continued loss of Louisiana's barrier systems would adversely impact the extraordinary scenic, scientific, recreational, natural, historic, archeological, cultural, and economic importance of these barrier islands. In addition, the continued loss of these coastal barrier systems would result in the reduction and eventual loss of the natural protective storm buffering of these barrier systems. Without the protective buffer provided by the barrier island systems, interior wetlands would be at an increased risk to severe damage from tropical storm events. Additionally, the continued shoreline recession and the movement of unstable sediments would undermine manmade structures, especially the extensive oil and gas pipelines and structures on this "working coast".

While all the barrier island systems in the study area would continue to experience varying rates of land loss, the greatest occurrence is within the Barataria/Terrebonne shoreline; this would continue. Additional information on the barrier island systems can be found in appendix D Louisiana Gulf Shoreline Restoration Team Report of the Main Report.

4.4.2 Restoration Opportunities - Direct Impacts

Direct impacts to barrier systems would primarily result from project-related activities that would immediately and directly create, restore, protect, rehabilitate, alter, or otherwise modify existing barrier systems.

RO1 (deltaic processes): There would be no direct impacts from RO1 on barrier systems as this restoration opportunity does not include any barrier system restoration features.

RO2 (geomorphic structure): There would be long-term significant beneficial direct impacts on barrier systems and short-term minor-to-moderate adverse impacts. Beneficial impacts include: restoration of approximately 32.2 miles of barrier systems. This includes restoration of about 8.0 miles of the Caminada-Moreau Headland, and about 3.2 miles of the Shell Island reach in Subprovince 2; restoration of about 3.4 miles of East Island, about 7.0 miles of Trinity Island, about 4.3 miles of Whiskey Island, and about 6.3 miles of East Timbalier Island in Subprovince 3. Additional long-term positive impacts include restoration and enhancement of the values and functions of these barrier systems. Short-term minor to moderate adverse impacts would be associated with restoration construction activities.

Barrier system restoration is based on preliminary designs developed in the presently ongoing LCA Barataria Barrier Shoreline Restoration Study. This restoration measure assumes a total 3,000-foot island footprint for restoration efforts in the Plaquemines and Bayou Lafourche barrier systems.

These areas contain some of the highest eroding barrier shorelines, headlands, and islands in Louisiana. RO2 would restore about 11 percent of Louisiana's barrier shoreline. Barrier system

restoration would also result in restoration of the physical diversity of the barrier system, which in turn would be positively reflected in the indirect impacts of increased biological vigor and diversity on the islands (after Britton and Morton 1989).

TSP: Direct impacts would be similar to RO2.

4.4.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to barrier systems would primarily result from long-term and far field effects to geomorphologic processes that influence barrier systems and the functions and values of these systems.

RO1 (deltaic processes): There would be no indirect impacts of RO1 on barrier systems as this restoration opportunity does not include any barrier system restoration features and any other project-induced indirect impacts would be negligible if any.

RO2 (geomorphic structure): Barrier system restoration, combined with interior marsh creation and restoration measures, would likely alter the tidal prism, thereby reducing formation of any additional tidal passes as well as "healing" (closing or narrowing) existing tidal passes and overwash areas. These different restoration measures would act together to retard saltwater intrusion into more northern portions of the basins.

Restoration of these barrier systems to near historic configurations, would, once again, provide natural storm buffering, limit storm surge heights, and provide protection for the interior wetlands, bays, and estuaries. In particular, restoration of the Caminada-Moreau Headland would provide protection for extensive oil and gas pipeline infrastructure and their landfall sites, especially for the nationally significant LOOP facility.

Estimates of about 61,100,000 cy of sands would be required for the first lift in restoring the Subprovince 2 and 3 barrier systems. Extraction (dredging) of offshore sand resources, such as at Ship Shoal, for restoration of these barrier systems, would indirectly impact the ecology of the borrow sites (see also section 4.2 Offshore Sand Resources).

The barrier shorelines and islands in Subprovince 2 and 3 support the commercial, recreational, and residential heartland of Louisiana's gulf coast. Fourchon Beach and Elmer's Island (part of Caminada-Moreau Headland) have been Louisiana recreational areas for generations. Cheniere Caminada is the site of a historic community destroyed by the hurricane of 1893. Along the Caminada-Moreau Headland, the Louisiana Offshore Oil Port, Inc. (LOOP) pipeline, the Shell Mars Pipeline, and pipelines from Amoco, BP, Chevron, Texaco, and others move millions of barrels of oil and billions of cubic feet of gas into America daily. Belle Pass is the entrance to Bayou Lafourche and Port Fourchon, the largest and fastest growing oil and gas port in the Gulf of Mexico and America. To the west, the Timbalier Islands support onshore and offshore oil and gas development and production. See also appendix D Louisiana Gulf Shoreline Restoration Team Report of the Main Report.

In addition, restoration of barrier systems would:

- restore critical piping plover shoreline habitat;
- restore the beach ecotone (i.e., the transition zone between the land and sea);
- restore essential fish habitat; and
- restore essential spawning, nursery, nesting, and feeding habitat for many different fish and wildlife species that presently must compete for these scarce barrier shoreline, headland, and island resources.

TSP: Indirect impacts would be similar to RO2.

4.4.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to barrier systems would primarily be related to the incremental impact of all past, present and future barrier system loss and restoration activities.

RO1 (deltaic processes): There would be no cumulative impacts of RO1 on barrier systems as this restoration opportunity does not include any barrier system restoration features.

RO2 (geomorphic structure): The long-term significant beneficial cumulative impacts include restoration of about 32.2 miles of eroding barrier shorelines, headlands, and islands compared to the continued loss of these critical resources if RO2 were not implemented. These potential gains in barrier system restoration are in contrast to the continued long-term significant adverse losses that would continue, to varying degrees, for the remaining 267 miles of Louisiana barrier shorelines in addition to the continued deterioration and losses of other barrier systems along the gulf.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.5 BARRIER REEF RESOURCES

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

4.5.1 Future Without-Project Conditions - The No Action Alternative

Reefs that have been mined in the past are considered separately from unmined reef areas in this section.

4.5.1.1 Previously Mined Barrier Reefs

These reefs formed under different geological conditions than occur now. Presently, Atchafalaya Bay is filling with Atchafalaya River sediments and the bay salinities are so diluted by Atchafalaya River flows that the Point Au Fer and Point Chevreuil reefs would not re-form naturally during the period being evaluated in this study.

Indirect impacts of the previously-mined reef future without-project conditions would include the following: continuation of altered estuarine hydrology, shoreline erosion in areas no longer protected by the barrier, reduced fish and shellfish productivity, reduced quality of fish and shellfish harvest areas, and improved navigation because of removed hazards to navigation.

The cumulative impact of future without-project conditions in the mined barrier reef area would be negative from a coastal wetlands protection, maintenance, or enhancement viewpoint. It would also be negative from a fish and wildlife resource standpoint, from a tidal flooding standpoint, and from an infrastructure standpoint.

4.5.1.2 Natural Barrier Reefs (Unmined Barrier Reefs)

The direct, indirect, and cumulative impacts of the unmined barrier reefs would be beneficial from a coastal wetlands protection and maintenance viewpoint. Physical, chemical, and biological conditions would not be expected to substantially change in the future; thus the remaining barrier reef complex should be maintained. With the future of the reef secure, it should continue to function as it has in the past and presently does. The barrier reef would continue to protect the Marsh Island gulf shoreline and adjacent wetlands. The reefs would continue to be a valuable fish and wildlife resource and would still provide recreational fishing areas.

4.5.2 Restoration Opportunities

There would be no direct, indirect, or cumulative impacts of RO1, RO2, or the TSP on barrier reefs as none of these restoration opportunities include any barrier system restoration features.

4.6 VEGETATION RESOURCES

4.6.1 Future Without-Project Conditions - The No Action Alternative

The preliminary modeling output provides predicted habitat type changes resulting from future-with- and future without-project conditions, expressed as acres (and square kilometers) of each of the major habitat types (**table 4-3**). The output from model calculations is a combination of two types of habitat change. The resulting acreage figures are the net result of habitat change due to land loss or gain, and habitat change due to conversion between habitat types. Separate acreage figures attributed to each type of change for each habitat are not available at this time, but may be provided as model refinement continues.

Table 4-3
Predicted Future Without-Project Wetland Habitat Acreage
By Subprovince in Louisiana Coastal Zone

Habitat Classes* (Acres)	Sub Province 1	Sub Province 2	Sub Province 3	Sub Province 4	Total LCA Area
Fresh Marsh	207,760	244,994	33,294	312,800	798,848
Intermediate Marsh	98,156	488	619,079	238,517	956,240
Brackish Marsh	142,972	52,168	40,046	202,292	437,478
Saline Marsh	54,802	0	5,355	0	60,157
Swamp/Wetland Forest	327,350	282,291	337,827	2,239	949,707
Total	831,040	579,941	1,035,602	755,848	3,202,431

* Wetland Shrub/Scrub habitat acreages were integrated into the broader model habitat classification.
Data sources numeric desktop model output

In a future without-project scenario, the model predicts a net loss of 13 percent in total acres of emergent wetland habitat coast wide. Gains and losses were forecast to occur for each habitat type that varied by subprovince, but the result on a coast wide basis was a net decline in every habitat type, except in intermediate marsh habitat. Model results show that saline marsh habitat would sustain the greatest loss, with a net decrease of 84 percent of total existing acres, followed by fresh marsh, swamp/wetland forest, and brackish marsh habitat, which were predicted to lose 15 percent, 9 percent, and 25 percent of existing acres respectively. Intermediate marsh habitat is predicted to increase a net 32 percent over existing acres.

The following subsections provide a general trend description by subprovince of the type and location of predicted habitat changes.

4.6.1.1 Subprovince 1- Mississippi River, Lake Pontchartrain, And Breton Basins

More than 5 percent of the total emergent wetland areas in Subprovince 1 are predicted to be lost in 50 years. Overall, the majority of direct land loss is expected to occur in the saline and brackish marsh habitats in the outer subprovince fringing Breton and Chandeleur Sounds. In addition, a freshening influence is expected, due to existing freshwater discharge in the upper and mid-subprovince areas with existing intermediate and brackish marsh habitat converting to fresh and intermediate marsh habitat respectively.

Modeling for future without-project, conditions predicts that swamp/wetland forest habitat would experience a small net decrease of 7 percent in total acres. Losses are anticipated to be of two

types: conversion to open water in the Lake Maurepas area, and conversion to intermediate marsh habitat, which would mainly occur adjacent to the Pearl River area.

The trend predicted for fresh marsh is a large net increase as fresh marsh areas expand to almost three times the current amount of existing acres. Gains in fresh marsh acreage are expected to occur almost exclusively through a freshening of existing intermediate marsh areas. The major portion of this conversion would occur in the upper Breton Basin in the Caernarvon outfall influence area, with another small portion in the area northeast of Lake Maurepas.

An approximate 40 percent net reduction in intermediate habitat acres is predicted to occur. Modeling results indicate that nearly all of the decrease in acreage would be due to conversion to fresh marsh habitat, although a small amount is anticipated to convert to open water in the lower subprovince. Modeling results also show that some gains in intermediate habitat acres would occur, mainly as a result of the freshening and conversion of existing brackish marsh areas located chiefly in the mid-subprovince surrounding the eastern shores of Lake Pontchartrain. A small amount of intermediate marsh habitat is also expected to be gained through conversion of swamp/wetland forest habitat.

An approximate 20 percent net decrease in brackish marsh acres is predicted, chiefly due to conversion to intermediate habitat. However, model output also predicts that a small amount of increase in brackish marsh acreage would occur due to conversion of saline marsh from a freshening influence along the eastern Lake Borgne shoreline and in the expanding Caernarvon influence area.

In saline marsh habitat, an approximate 50 percent net decrease is expected. A portion of that decrease is predicted to be due to conversion to brackish habitat, and the remainder would be due to direct land loss in the outer subprovince as outlying marshes succumb to marine processes.

The proportional distribution of habitat types in Subprovince 1 is anticipated to continue to reflect a gradient salinity zone, but is predicted to be more heavily weighted in the fresh regimes. Fresh marsh and swamp/wetland forest habitats are predicted to make up the largest portion of emergent habitat acres (65 percent) and saline marshes the smallest (7 percent). Vegetative productivity is predicted to increase a very small amount.

4.6.1.2 Subprovince 2- Mississippi River and Barataria Basin

Approximately 22 percent of the total existing emergent wetland acres are predicted to be lost in 50 years. The majority of land loss is expected to occur throughout the lower subprovince, in the saline and brackish marsh habitats, increasing in magnitude as the Gulf of Mexico is approached. Anticipated freshwater inputs are also expected to greatly expand the area of fresh conditions southward so that existing intermediate marsh habitat would convert to fresh marsh habitat, and any remaining brackish and saline habitats not converted to open water would convert to fresh and intermediate habitat respectively.

Swamp/wetland forest habitat is predicted to remain relatively stable throughout the subprovince, with less than a net 4 percent decrease in total acres.

Some loss is expected to occur in fresh marsh habitat from fragmentation and conversion to open water, mainly in marshes in the Lake Salvador region. Regardless, a large net gain of 35 percent in total fresh marsh acres is anticipated. A major freshening trend is expected from the increasing influence of existing freshwater diversions. Nearly all existing emergent intermediate and brackish marsh acres expected to endure the next 50 years are anticipated to convert to fresh marsh habitat.

Modeling results predict that intermediate marsh acres will have a net decrease of almost 100 percent. Actual decrease will be dependant upon the future operation of some existing diversions. Some loss is expected through conversion to open water but, as described above, most of the decrease in acreage is from the freshening of existing intermediate habitat and conversion to fresh conditions due to the expanding influence of freshwater discharge. Some gain in intermediate acres is also expected from the freshening of saline marshes currently existing adjacent to the Mississippi River.

Brackish marsh acres are also predicted to decrease 20 percent to 100 percent depending on future diversion operation. Decline in brackish marsh acreage will be largely due to conversion to fresher habitat type. Nevertheless, a significant portion of the decrease in brackish marsh acres is also expected to occur due to direct loss of emergent land and conversion to open water.

A 100 percent decrease of existing saline marsh acres is expected. Direct loss of a large portion of existing acres is predicted through direct emergent land loss in the lower subprovince. Loss of saline marshes through conversion to open water is predicted to be especially severe in the southwest part of the subprovince. A portion of the saline marshes currently existing adjacent to the Mississippi River is also expected to convert to intermediate marsh.

The predicted proportional distribution of habitat types throughout Subprovince 2 reflects the decrease in habitat diversity that is expected as the more saline marshes are lost or converted to fresher conditions. Of the remaining acres of emergent habitat in the subprovince, over 90 percent will be divided evenly between fresh marsh and swamp/wetland forest habitats, and the other 9 percent will be either intermediate or brackish marsh. It is likely that a very narrow band of saline marsh habitat will occur along the coastal shoreline as a result of the continued estuarine influence in the lower subprovince, but it would be of such a small scale that the effect is not captured in the model. Vegetation productivity is expected to decrease by 25 percent.

4.6.1.3 Subprovince 3- Teche/Vermilion, Atchafalaya, And Terrebonne Basins

Approximately 16 percent, or over 200,000 acres of existing emergent wetland habitat will be lost through conversion to open water. The majority of direct land loss will occur in the eastern subprovince, with land loss increasing in magnitude from north to south. Habitat zones are expected to narrow and shift northward in that area in response to loss of buffering emergent marsh in the face of encroaching salinity. Considerable land gain is expected in the central subprovince due to continuing Atchafalaya River Delta development, and fresh conditions are expected to continue expanding into the western subprovince.

The desktop numerical output of the model shows a net 13 percent loss in swamp/wetland forest habitat in the next 50 years. Based on previous and ongoing studies by the USACE and comments received from land managers at the June 2003 LCA Comprehensive Study public meetings, deterioration of the swamps east of Lakes Palourde and Verret may be occurring due to sustained elevated water levels in the upper Atchafalaya Basin. Therefore, it is reasonable to expect that some loss will occur in the swamp/wetland forest habitat in this subprovince.

A net decrease of 90 percent is predicted in fresh marsh habitat. The model output indicates that this decrease in acres will be almost entirely from conversion to intermediate marsh habitat in the expanding area of Atchafalaya River influence. This may be correct within the constraints of the modeling effort because the habitat-switching module has a salinity level of 2 parts per thousand (ppt) established as the threshold between fresh and intermediate marsh. Combining parts of west Terrebonne Basin with the Atchafalaya Basin into one hydrologic unit, from which an average salinity is derived, may have yielded a salinity level slightly above 2 ppt.

A net increase of 220 percent is predicted in intermediate marsh habitat. This predicted increase is due to large areas of fresh marsh converting to intermediate habitat. All land newly built from Atchafalaya River Delta development is predicted to be intermediate marsh habitat as well. This may be correct within the threshold constraints of the modeling effort as described above. Additional gains are also predicted to occur where all brackish and saline areas in the western subprovince, in the Teche/Vermilion Basin, and in the lower southwestern Terrebonne Basin are predicted to convert to intermediate marsh as the freshening influence of the Atchafalaya River expands. Some decrease in acres of intermediate marsh habitat is also anticipated as a result of switching to a brackish habitat and direct land loss in the Terrebonne Basin, and as a result of a small amount of direct land loss in the Teche/Vermilion Basin.

A net decrease of over 80 percent in brackish marsh acres is predicted to occur in Subprovince 3. Changes in existing brackish marsh habitat will occur in the eastern and western portions of the subprovince. Predicted reduction in areas of brackish marsh habitat in the Teche/Vermilion Basin is due primarily to conversion to intermediate marsh habitat, but a small amount of direct loss will occur. In the Terrebonne Basin, the predicted decrease of brackish habitat will be due to a combination of direct land loss and shifts to other habitat types in both directions of the salinity gradient. Brackish marshes in the vicinity of Atchafalaya River influence are expected to change to intermediate marsh, while those to the east are predicted to change to saline marsh or open water.

A net decrease of over 95 percent in saline marsh acres is predicted to occur in Subprovince 3. A small amount of saline marsh acres will be converted to intermediate marsh, but the majority of loss is indicated to be direct land loss as the eastern Terrebonne marshes erode and subside from lack of freshwater and sediment input.

The anticipated freshwater and sediment inputs from the Atchafalaya River will greatly freshen the central and western areas of Subprovince 3, while fragmentation and shoreline erosion will cause all habitat types in the east to be subjected to direct loss. As a result, almost 60 percent of the acres of emergent wetland habitat that is remaining in 50 years is predicted to be intermediate marsh, 3 percent will be fresh marsh habitat, 4 percent will be brackish marsh, less than 1 percent

will be saline marsh, and 33 percent will be swamp and wetland forest. Vegetative productivity is anticipated to decrease by more than 30 percent.

4.6.1.4 Subprovince 4-Calcasieu/Sabine and Mermentau Basins

Approximately 43 percent of the total emergent wetland acres in the subprovince are fresh marsh habitat, mainly located in the northern, eastern and mid-subprovince. Less than 1 percent of the emergent wetland acres are swamp/wetland forest habitat. Approximately 35 percent of emergent wetland acres are intermediate marsh located in the extreme western and eastern areas of the subprovince and in a few pockets transitioning between fresh marsh and brackish marsh habitat areas to the south. Approximately 17 percent of emergent wetland acres are brackish marsh habitat that mainly occurs in the marshes adjacent to Calcasieu Lake and in an inland zone parallel to the narrow band of saline marsh habitat bordering the Gulf of Mexico shoreline. Saline marsh habitat composes only 4 percent of the emergent wetland habitat in this subprovince.

Almost 6 percent loss of emergent wetland habitat is expected in 50 years throughout Subprovince 4. Increasing saltwater intrusion, particularly in the western half of Subprovince 4 and at the extreme eastern subprovince boundary, will drive transition of existing vegetated habitats to saltier regimes. Direct land loss through subsidence and increased hydrologic connection will also continue.

Nearly 40 percent of swamp/wetland forest habitat acres are predicted to decrease, although this amount is actually small due to the fact that there is less than 4,000 acres currently existing. The decrease will be due to increasing salinities in the western half of Subprovince 4, particularly in the northern areas east and west of Calcasieu Lake.

A net decrease of 10 percent is expected to occur in the total existing amount of fresh acreage. A large portion of that decrease will be due to increasing salinity causing eventual conversion to brackish marsh habitat in the western subprovince in the Calcasieu and Sabine Lakes system, and conversion of a small amount of fresh marsh acres to intermediate habitat between Grand Lake and Highway 82 in the central subprovince. Also, decreases are expected from direct land loss in existing emergent fresh areas between Sabine, Calcasieu, and Grand Lakes, as increasing salinity and hydrologic connections cause open water areas to expand and coalesce.

A net decrease of 16 percent of existing intermediate marsh acres is predicted. The majority of the decrease will be due to increasing salinity causing existing intermediate habitat to shift to brackish marsh habitat. Transition in habitat type is expected to occur in the Calcasieu and Sabine Lakes systems in the western subprovince, in the lower eastern subprovince south of Highway 82, and the extreme eastern end of the subprovince adjacent to Freshwater Bayou. Also, some direct loss is expected as intermediate habitat converts to open water.

Brackish marsh habitat is predicted by the model to expand northward from the Gulf of Mexico and through the Calcasieu Lake system to almost 150 percent of current acreage, but the increase will be almost entirely due to conversion of fresh, intermediate, and saline marshes. No brackish marsh acreage is expected to be gained through the formation of new land areas. Additionally,

some direct loss due to conversion of brackish habitat to open water is expected south of Highway 82.

Nearly all of the pockets of saline marsh habitat in Subprovince 4 are predicted to be converted to brackish marsh habitat in 50 years. Some direct loss through fragmentation and conversion to open water in existing saline habitats south of Highway 82 is also expected.

While much of the existing fresh marsh habitat in Subprovince 4 is predicted to remain intact in the eastern and mid-subprovince areas, brackish regimes expanding in western areas of the subprovince will somewhat reduce the combined dominance of fresh and intermediate marsh habitat in Subprovince 4. Proportionally, brackish marsh habitat is predicted to compose approximately 27 percent of the total of emergent wetland habitat acres remaining in 50 years. The composition of the balance of emergent acres will be 41 percent fresh marsh and 32 percent intermediate marsh. With the 6 percent direct loss of emergent acres, and minor changes in the proportional distribution of habitats, vegetative productivity is expected to decrease less than 4 percent.

4.6.1.5 Invasive Species - Future Without-Project Conditions

Louisiana's geographic location, features, and subtropical climate make it a portal for invasive species through several mechanisms of intentional and non-intentional introduction, as it hosts global transportation centers and corridors, a large human population of diverse ethnicity, and large expanses of disturbed ecosystems within a variety of habitat types. Expanding awareness of the threats posed by invasive species has recently resulted in increased efforts in Louisiana to mitigate, control and prevent invasive species through institutional recognition, policy development, programmatic and private efforts by state and federal agencies, universities, non-governmental organizations (NGO), local organizations and citizens (see list).

The seriousness of the problems frequently caused by invasive plants has been recognized for some time, and the ecological damage that invasive plants create or aggravate have resulted in the development of national and regional programs to respond to the challenge of reducing the harmful effects of invasive plants. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646), although aimed primarily at the zebra mussel, *Dreissena polymorpha* (Pallas), also applies to invasive plants.

Executive Order 13112, signed by the President on February 3, 1999, specifies that all Federal agencies must prevent the introduction of invasive species, to the extent possible within their programs, and not take actions that would cause or promote the introduction or spread of invasive species. EO 13112 also provides for the establishment of an Invasive Species Council to provide national leadership in dealing with invasive species.

The Center for Aquatic and Invasive Plants, based at the University of Florida, receives significant support from the Bureau of Invasive Plant Management, Florida Department of Environmental Protection and the Aquatic Plant Control Research Program, USACE. Public concern about the problems caused by invasive species continues growing, with many private groups and non-governmental organizations (NGOs) researching aspects of the invasive species

problem and working toward solutions. These efforts will likely continue and probably expand, because the frequency of invasive plant introductions is increasing with the increasing volume and speed of international trade.

Nevertheless, with no action, invasive species will likely continue to pose a threat to the floristic integrity of Louisiana's coastal ecosystems as massive landscape disturbance and deterioration is prolonged, stressing the balance that evolved between Louisiana's native vegetative communities and their habitat. Degrading native vegetative communities will become increasingly vulnerable to infestation and, eventually, replacement by invasive species that out-compete native species and aggressively develop dense monocultural stands. Some benefit may be realized from establishment of invasive species. For example, the robust above- and belowground production of Cogon grass may provide substrate stabilization and biomass contributions, or water hyacinth may provide potential water quality improvement through nutrient uptake and retention, but the potential benefits are not expected to outweigh overall impacts anticipated from the proliferation of invasive species. Expected major impacts caused by spread of invasive species are reduced vegetative biodiversity, alteration of abiotic factors and coastal ecosystem processes, and reduction of wildlife food and habitat.

4.6.1.6 Summary of Future Without-Project Conditions - The No Action Alternative

Several natural and human-induced factors that recently interrupted the natural progression of coastal landbuilding and degradation have likewise affected the vegetative communities. Wetland plants play a critical role in the maintenance and protection of coastal lands. If unchecked, stressors will continue to alter the conditions that affect survival and production of wetland species.

Direct loss of vegetated habitat will continue to occur as plants are physically removed by erosion from marine processes and increased water velocities, and increased herbivory pressures. Changes in environmental conditions that occur quickly or beyond the tolerance limits of plant species to adapt or allow succession, will cause conversion directly to open water. Continued subsidence and other factors that will facilitate increased flooding and saltwater intrusion will cause complete die-off of the more vulnerable plant communities. In particular, large-scale loss of protective land forms, such as elevated ridges and islands, landbridges, and contiguous fringing marshes, that buffer the rare or unique vegetative communities or vulnerable vegetative habitats formed in highly organic conditions will result in habitat conversion or loss. Although submerged aquatic vegetative habitat was not addressed by the model, it can be speculated that increased erosion and water exchange will also cause changes in water temperatures, deepening of shallow water areas, and drive turbidity increases that will cause decreases in the presence and productivity of submerged aquatic vegetation.

The multiple benefits derived from the attributes and functions of wetland vegetation become indirectly impacted by the decline and loss of vegetative habitats. Louisiana plant species and communities vary widely in their abilities to adapt to a variety of environmental conditions. In habitats where variation in conditions becomes restricted, such as those with extreme salinity, water depths, or sediment and nutrient deprivation, species diversity will be severely reduced.

Ultimately, species distribution and successional patterns of plant communities will be negatively influenced and only those communities of species that can adapt to severely limited conditions will endure. Sustained environmental stressors causing declines in plant production will also result in biomass deficits. As a result, accumulation of the decomposing organic material that contributes to the structure and vertical accretion of soils will be reduced, carbon sequestration will diminish, and the contribution that serves as the basis of the trophic chain will be curtailed. Deterioration and loss of emergent and submerged plant communities will cause decline in the protection against substrate erosion, water quality improvement, and the contribution of food and physical structure for cover, nesting and nursery habitat for wildlife and fisheries. Loss of stabilizing vegetative cover increases the exposure of wetland soils to increased particle detachment, export out of the system, and further loss of elevation.

Continued degradation and loss of existing wetland vegetative habitats, in concert with truncation of replenishing processes will accelerate declines in the interdependent processes of plant production and vertical maintenance necessary for persistence of a stable ecosystem. Without action, future wetlands loss will continue. The model predicts that a net decrease of 462,760 acres of total wetland vegetative habitat will occur. The predicted net changes in each habitat type modeled is: a decrease of 141,960 acres fresh marsh, an increase of 231,950 acres of intermediate marsh, a decrease of 147,050 acres of brackish marsh, a decrease of 314,620 acres of saline marsh, and a decrease of 91,080 acres of swamp/wetland forest. Additionally, if investment in the maintenance of existing restoration efforts is discontinued, accelerated loss may also occur in vegetative habitats currently under protection. Since the LCA contains 40 percent of the nation's wetlands, and is experiencing 80 percent of the loss, the potential impacts to other significant resources dependent upon Louisiana's vegetative habitat and the associated functions and values will be cumulatively severe on a state, Gulf of Mexico regional, and national level.

4.6.2 Restoration Opportunities - Direct Impacts

Direct impacts to vegetation resources would primarily result from those project-related activities that would directly create, disturb, destroy, or otherwise harm existing vegetation resources. For example, a vegetative planting in a marsh creation area would directly create or restore vegetation resources in the planted area. Direct impacts from installation of structural measures (e.g., diversions and guide channels) or placement of dredged material on vegetative habitat would occur only where existing vegetation within the direct footprint of the construction work is disturbed, destroyed, or otherwise harmed. Impacts to vegetation within the influence area of a diversion's discharge would be considered in the indirect impacts section.

Precise calculation of the acres of wetland vegetative habitat that would be directly impacted from the construction or implementation of each plan would be performed when more detailed analysis is conducted for restoration feature-specific studies.

RO1 (deltaic processes): Since this alternative's proposed features are composed almost entirely of freshwater reintroductions and provisions for freshwater redistribution, direct, long-term impacts to a negligible amount of vegetation resources are expected to occur in the construction footprint areas of diversion and water control structures, new guide levees, and channel widening

excavation. Direct impacts could also occur in the footprint of bank repair work in areas where wetland vegetation now occupies eroded sections. Dedicated dredging, such as in the vicinity of Myrtle Grove, would create marsh vegetation.

The diversions and marsh creation restoration features of RO1 could potentially increase the opportunities for the spread of invasive plant species onto newly created or restored wetlands. However, proper design elevations, at marsh restoration sites, to target elevations that favor colonization by native species while reducing the elevation zone favorable to some invasive species is one method to reduce the likelihood of spreading invasive species. In addition, best management practices for vegetation restoration would include replantings utilizing native plant species for all LCA projects. Additional research, such as could be conducted under the auspices of the LCA Science and Technology, would need to be accomplished to further address this potential problem.

RO2 (geomorphic structure): Because activities associated with the restoration of geomorphic structures or geomorphic structure function, comprise this alternative, a negligible amount of long-term direct impacts will occur to vegetation resources that are present within the construction footprint of any structure. In addition, short-term, direct impacts may occur from marsh creation or barrier island restoration efforts where existing wetland vegetation is overlaid with deposited sediments. Conversely, vegetation resources would be directly created on all marsh creation or barrier island restoration areas that are planted. At this time, it is not possible to discern proportional differences or similarities between this restoration opportunity and RO1 in the amount of vegetation resources that will be directly impacted. Nevertheless, this restoration opportunity can be expected to directly create more vegetated habitat than RO1.

Restoration of Louisiana's barrier islands, headlands, and shorelines, along with marsh creation and beneficial use of dredged material of RO2 could potentially increase the opportunities for the spread of invasive plant species onto newly created or restored wetlands. However, proper design elevations at marsh restoration sites to target elevations that favor colonization by native species while reducing the elevation zone favorable to some invasive species is one method to reduce the likelihood of spreading invasive species. In addition, best management practices for vegetation restoration would include replantings utilizing native plant species for all LCA projects. Additional research, such as could be conducted under the auspices of the LCA Science and Technology, would need to be accomplished to further address this potential problem.

TSP: Given that the set of measures in this alternative is equivalent to the combination of RO1 and RO2 measures, excluding one shoreline protection measure and one landbridge protection/restoration measure, the direct impacts to vegetation resources would be nearly equivalent to the combination of direct impacts that would occur from implementation of both RO1 and RO2. In addition, the direct creation of vegetated habitat would be nearly equivalent to the combination of RO1 and RO2 created habitats.

The synergistic interactions of freshwater diversions, restoration of Louisiana's barrier islands, headlands, and shorelines, along with marsh creation and beneficial use of dredged material could potentially increase the opportunities for the spread of invasive plant species onto newly

created or restored wetlands. However, proper design elevations at marsh restoration sites to target elevations that favor colonization by native species while reducing the elevation zone favorable to some invasive species is one method to reduce the likelihood of spreading invasive species. In addition, best management practices for vegetation restoration would include replantings utilizing native plant species for all LCA projects. Additional research, such as could be conducted under the auspices of the LCA Science and Technology, would need to be accomplished to further address this potential problem

4.6.3 Restoration Opportunities - Indirect Impacts

Indirect impacts are those effects that are caused by the action and are later in time or further removed in distance, but are still reasonably foreseeable. Indirect impacts may include changes in vegetation growth and productivity, changes in the pattern of vegetation zones, and other effects.

With all restoration opportunities, loss of vegetated habitat is expected to continue from natural and human induced factors in some areas, but is expected to be somewhat offset by the development of vegetated habitat in created areas or areas of land building. Nevertheless, the sediment and nutrient input measures and key structural protection of the restoration opportunities are expected to reduce mortality and decrease the loss of vegetated habitats due to flooding and saltwater intrusion. The changes to habitat type will be the result of either or both habitat change due to land loss or gain, and habitat change due to conversion between habitat types. Separate acreage figures attributed to each type of change for each habitat are not available at this time, but would be determined in future project-specific studies.

Vegetative productivity (i.e. production of organic matter) is dependant upon species/community composition and vegetative response as regulated over time by forcing functions such as salinity, inundation, and nutrient availability, among others. Consequently, the effects of the various actions on productivity are considered to be indirect impacts because changes would occur as vegetation responds over time to the changes in forcing functions.

RO1 (deltaic processes): In response to freshwater and sediment diversions, and the associated increased nutrient input and freshening of salinity regimes (see section 4.3 Salinity Regimes), indirect impacts of RO1 would include: long-term minor to significant reduction in losses of coastal vegetation in general, and protection of fresh and intermediate marsh, and swamp-wetland forest in particular. Conversion of marsh types to fresher habitat with the associated increases in vegetative productivity is also expected in some areas compared to future without-project conditions. Newly created land in diversion outfall areas adjacent to the Mississippi River and other areas receiving Atchafalaya River influence, would be expected to be fresh or intermediate habitat.

In Subprovince 1, the salinities in the Lake Borgne area and those portions of the upper Breton Sound influenced by the freshwater discharges would freshen compared to the future without-project conditions thereby reducing the suitability of these areas to more saline-tolerant species. Conversion to fresher habitat types would be most likely in the Breton Sound area. Overall, freshwater and sediment input would improve vegetative productivity and reduce the rate of loss

of all vegetative habitats throughout the subprovince, with the exception of barrier shoreline vegetation.

In Subprovince 2, the mid- and upper subprovince areas would remain fresh habitat, however additional sediment and nutrient input can be expected to increase productivity and reduce the rate of loss of emergent habitat. Marsh creation in the Myrtle Grove area would also offset some fresh marsh loss, help protect the mid-subprovince wetlands, and contribute additional vegetative production. In the lower subprovince, the salinities in the Caminada Bay and Caminada-Moreau Headland area would slightly freshen from the future without-project conditions, thereby somewhat reducing the suitability of these areas to more saline-tolerant species. A sufficient level of freshening may drive conversion from saline and brackish marsh habitats to brackish and intermediate marsh habitats respectively, with a concurrent increase in productivity and reduction in loss rates.

In Subprovince 3, the salinities in the upper reaches of the Terrebonne and Timbalier Bays would slightly freshen from the future without-project conditions, thereby somewhat reducing the suitability of these areas to more saline-tolerant species. Small inputs from reintroduction and improved distribution of freshwater and nutrients would enhance vegetative productivity and optimize conditions for maintenance of all vegetative habitats, resulting in some reduction in the rate of loss of emergent habitat, with the exception of barrier shoreline vegetation.

There would be no restoration features in Subprovince 4; hence, there would be no indirect impacts.

RO2 (geomorphic structure): Indirect impacts would include long-term minor to significant increases in coastal vegetation in general, and all vegetation types, especially barrier shoreline vegetation. Because the salinity regimes would not appreciably change from future without-project conditions, contributions to all vegetative habitat types would be made as a result of new vegetative community development and stabilization of existing habitats facilitated only by the marsh creation, barrier shoreline restoration, and MRGO environmental restoration features. Contributions to vegetative productivity would come from expansion of new vegetative habitat on newly created areas and the relief from flooding and saltwater intrusion stressors that those areas would afford existing habitats.

TSP: The combination of almost all of the RO1 and RO2 features of sediment and nutrient input and as well as key structural protection is expected to reduce vegetative mortality, increase productivity and decrease the loss of vegetated habitats due to flooding and saltwater intrusion, as well as promote formation and development of new vegetative communities in areas of all habitat types in all subprovinces. The functional interaction of the combined measures in Subprovinces 1 through 3 is expected to yield a synergistic effect on resulting benefits in all habitat types. As a result, the increases of new habitat, vegetative productivity, and protection of existing habitat, along with the decrease in habitat loss for the TSP, should be greater than the combined amount of those benefits attributed to RO1 and RO2, individually.

4.6.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. The cumulative impact to wetland vegetation resources is the aggregate result of all impacts from a plan which are incremental, i.e. additive, to impacts of other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time. The net change of each vegetative habitat type is not available at this time, but would be determined in future project-specific studies.

RO1 (deltaic processes): Over the 50-year project life, a net decrease in total wetland vegetative habitats would occur, however the overall rate of loss compared to future without-project conditions would be reduced. The net reduction in loss rates would likely be greatest with fresh and intermediate marsh and swamp/wetland forest habitat, where the influence of freshwater and nutrient inputs and potential for land building is greatest; however brackish and saline marsh areas would also experience some reduction in the rate of loss. The rate of loss of barrier shoreline vegetation would likely remain similar to the future without-project conditions due to the fact that the RO1 features do not address the major causes of loss that have been identified in this habitat.

RO2 (geomorphic structure): Over the 50-year project life of this restoration opportunity, a net decrease in total wetland vegetative habitats would be predicted to occur, although the overall rate of loss compared to future without-project conditions would be expected to be reduced. Loss rates for each habitat type would be anticipated to be reduced as the RO2 features would provide protection to some existing marsh habitats, and newly created areas would be added in all wetland vegetative habitat types (depending upon the locations of created areas).

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

The incremental impact of each plan should be considered along with that of a future without-project conditions. In the future without-project conditions, preliminary modeling predicts that a net decrease of 462,760 acres of total wetland vegetative habitat would occur in Louisiana. An estimate of existing coastal wetlands in the continuous United States using USFWS National Wetland Inventory Data is 4,500,000 acres fresh marsh habitat, 4,000,000 acres non-fresh marsh habitat, and 17,300,000 acres forest and shrub/scrub habitat, for a total of 25,800,000 acres (Field et al., 1991). At roughly 2.5 million acres of coastal marsh habitat, Louisiana accounts for approximately 30 percent of total coastal marsh habitat in the lower 48 states. Louisiana also accounts for 90 percent of the total loss of those marshes (personal communication with J. Johnston 2003, Field et al., 1991, Dahl 2000, and Barras et al., 2003).

Long term rehabilitation and maintenance of wetland vegetative habitats would prevent decline in the inter-dependant processes of plant production and vertical maintenance necessary for the persistence of stable ecosystems. With implementation of a near-term course of action, vegetative habitats restored or protected by current investment in existing restoration efforts could also be enhanced and prolonged. The reduction of loss would help reduce the potential

cumulative impacts and prolong other dependent resources that are significant on a state, regional, and National level.

4.6.5 Invasive Species

Many factors combine to influence the probability of successful establishment of invasive species. Each invasive species is uniquely regulated by a particular combination of environmental factors and an individual propensity to infiltrate an area. Also, natural vegetative communities vary in their inherent susceptibility to being invaded, which is additionally influenced by the particular level of stress impinging on an area. Therefore, at this juncture, it is not possible to accurately predict invasive species impacts resulting from implementation of the RO1, RO2, or the TSP. Invasive species concerns will be addressed on a project-by-project basis in the feasibility phase when the detailed evaluation and development of alternative measures is conducted and potential impacts are assessed.

In general, restoration of geomorphic features, such as with RO2, can be expected to reduce stress on existing communities by buffering marine encroachment and preventing increased hydrologic exchange, while increased delivery or improved distribution of fresh water and nutrients, as with RO1, is anticipated to nourish, enhance production, and support diversity of natural vegetative communities, reducing their vulnerability to invasive species threats. Since the TSP is essentially a combination of the RO1 and RO2 approaches, greater potential benefits could be expected via enhancement and protection of natural vegetative habitats, as well as improving resistance to infiltration by invasive species. Conversely, system freshening and newly created habitat may provide additional habitat where conditions are favorable for encroachment by invasive species; however, newly created areas can also provide opportunity to establish more diverse communities composed of native species.

To meet the challenge of established non-indigenous species and future introduction of non-indigenous species requires policy development, enforcement, education and research. Implementation of a non-indigenous species policy demands a firm scientific basis, which will require the acquisition of information not currently available. Our knowledge of biology, physiology, ecology, and behavior of most non-indigenous species is rudimentary at best. Research in these areas is critical to understanding the nature of biologic invasions and how to prevent or limit their effects" (Mac et al., 1998). For the LCA, perhaps that acquisition of information for Louisiana restoration efforts could be performed through the LCA Science and Technology efforts.

The risk of invasive species will be considered in the planning process for each LCA restoration feature and, where necessary, appropriate steps will be taken to reduce that risk and protect against or mitigate for invasive species impacts. These steps could include appropriate interdisciplinary coordination throughout all phases of planning and implementation; establishing the rigor of monitoring protocols necessary to stress identification, early detection, and response to invasive species dispersal; coordination with available nuisance species programs in Louisiana; and use of native species plantings to quickly establish targeted vegetative communities.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.7 WILDLIFE RESOURCES: BIRDS, MAMMALS, AMPHIBIANS AND REPTILES

See also appendix A1 "U.S Fish and Wildlife Service Planning Aid Input" for this PEIS and appendix B4 U.S. Fish and Wildlife Coordination Act Report regarding the comprehensive LCA effort, and appendix B5 U.S. Fish and Wildlife Coordination Act Report for the LCA near-term course of action.

4.7.1 Future Without-Project Conditions - The No Action Alternative

The projection of wildlife abundance is based almost exclusively on the predicted conversion of marsh to open water and the gradual sinking and resultant deterioration of forested habitat throughout the study area. Numerous other factors, including water quality, harvesting level, and habitat changes elsewhere in a species' range cannot be predicted and were not considered in these projections. Therefore, the projections presented are to be viewed and used with caution.

4.7.1.1 Coast wide

Louisiana's coastal wetlands are predicted to suffer extensive land loss and habitat change by the year 2050. The effect of such losses and changes will likely result in a decrease in the abundance of wildlife as marshes, forested wetlands, and their associated habitats continue to deteriorate and convert to open water. Populations of resident and migratory birds and other animals directly dependent on the marsh and swamp will decrease dramatically, an impact which will be felt in much of North America, where some of these species spend part of their life cycle. The bald eagle and brown pelican are recovering from very low populations experienced over the last three decades. Increasing populations for those two species are projected to continue in the future, independent of near-term wetland changes.

Forested habitat in the study area serves as vital resting and foraging habitat for trans-gulf neotropical migrant birds (they tend to choose wooded chenier ridges). Of those few remaining ridges, only small patches support forested habitat. As the ridges continue to subside below elevations that can support forested habitat, great numbers of neotropical migrants will be negatively affected.

The fate of other species groups in coastal Louisiana will be influenced by habitat conditions. These groups include migratory birds, such as wintering waterfowl, which rely on the abundant food supply in coastal wetlands to store energy reserves for migration and nesting (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998).

4.7.1.2 Subprovince 1 - Pontchartrain Basin, Breton Basin, and Eastern Mississippi River Delta

Habitat quality for wildlife is expected to decline as the marshes of this subprovince continue to deteriorate and convert to open water under future conditions with no action. Losses are expected to be concentrated in the middle and lower subprovince and on the land bridges. Significant losses of swamp could occur in the upper subprovince.

Brown pelican and bald eagle numbers are projected to increase in areas presently occupied, primarily as the result of nesting success projected in this subprovince and other areas of the coast. Seabird abundance is expected to decrease in the lower basin and in the Bonnet Carré and La Branche wetland area. Shorebird abundance is expected to decrease in areas of high land loss in the lower subprovince. Wading bird numbers are expected to decrease in areas surrounding Lake Borgne. The numbers of ducks are expected to decline in much of the area and to increase in the vicinity of the Caernarvon freshwater diversions. The abundance of other birds using marsh and open water habitats is projected to decrease in deteriorating wetlands. Furbearer and game mammal numbers are expected to decrease in the lower subprovince where high land loss is expected. Alligator abundance in the upper subprovince is expected to increase with an increase in open water and non-forested wetland habitats.

4.7.1.3 Subprovince 2 - Barataria Basin and Western Mississippi River Delta

Habitat quality for wildlife is expected to decline as the marshes of this subprovince continue to deteriorate and convert to open water under future without- project conditions. Freshwater inputs through the siphons at Naomi and West Pointe a la Hache, the navigation locks at Harvey and Algiers, and the West Bay and Davis Pond Freshwater Diversions are expected to enhance conditions for wildlife in those areas.

Ducks are expected to increase or remain steady in areas receiving freshwater input, but decline in the lower region marshes where wetlands will continue to be lost. Seabird, wading bird, and shorebird abundance is expected to decrease in areas of high land loss, primarily in the lower portion of the subprovince, and is expected to remain steady in other parts of the subprovince primarily due to the West Bay and Davis Pond diversions. Geese abundance is expected to decrease in the Mississippi River Delta and the Grand Liard area, and increase in the West Bay area. The abundance of other birds using marsh and open water habitats is projected to decrease in deteriorating wetlands and increase in land-building areas such as West Bay. Brown pelican and bald eagle numbers are projected to increase in areas presently occupied, primarily as the result of nesting success projected in this subprovince and other areas of the coast. Decreased numbers of raptors and other woodland birds are expected across the subprovince, except in areas influenced by river diversions.

As the few remaining wooded chenier ridges continue to subside below elevations that can support forested habitat, greater numbers of neotropical migratory birds will be negatively affected. Furbearer and game mammal abundance are projected to decrease. Generally, direct harvest, and the loss and degradation of habitat have resulted in depletion of many reptiles and

amphibians in the basin (Condrey et al., 1995). Alligator numbers are projected to decrease in areas expected to experience high land loss.

4.7.1.4 Subprovince 3 - Terrebonne, Atchafalaya, and Teche/Vermilion Basins

Forested wetlands of the Terrebonne Basin are expected to change to a more frequently flooded, less diverse community, as a result of subsidence and increasing water levels. This habitat change is expected to cause a decrease in several bird species, which utilize those habitats. However, bald eagle numbers are expected to increase as their preferred nesting habitat, cypress swamp, increases. Game mammals such as white-tailed deer, squirrels, and rabbits are expected to decline. American alligator populations are expected to increase with an increase in open water, swamp, and non-forested wetland habitats.

The greatest threat to fish and wildlife resources across Subprovince 3 is the ongoing loss of coastal wetlands in the Terrebonne Basin. In the eastern Terrebonne Basin most wildlife populations are expected to decline due to high land loss. In central Terrebonne Basin, waterfowl, seabirds, shorebirds, raptors, and marsh and woodland resident and migrant species are all expected to decline. Brown pelican populations are expected to increase, as are the bald eagle populations in the Penchant marshes where nesting activity is high in swamp habitat adjacent to fresh marsh. American alligator populations will likely decline in the Mechant/De Cade area, but are projected to increase in the Penchant marshes due to an increase in Atchafalaya River influence. In the extreme western portion of the Terrebonne Basin, most wildlife populations are expected to remain steady. Marshes adjacent to the Atchafalaya River will continue to receive abundant fresh water, nutrients, and sediments; hence, they will likely remain healthy and provide quality habitat for wildlife.

As the Atchafalaya Delta continues to grow, habitat value for wildlife will increase, especially for waterfowl. The brown pelican is also projected to increase, but primarily as the result of nesting success projected in other areas of the coast. American alligator populations are expected to continue increasing across this basin.

In the Teche/Vermilion Basin projected land loss rates are expected to remain relatively low. As a result of relatively stable wetland conditions projected for most of the basin, most wildlife populations are expected to remain stable.

4.7.1.5 Subprovince 4 –Calcasieu-Sabine and Mermentau Basins

The abundance of waterfowl, seabirds, shorebirds, and resident and migrant marsh birds will generally remain steady or increase within most of the subprovince except for those Calcasieu areas not under the protection of salinity control structures. Wading bird populations, which are presently experiencing increases in most areas, are expected to level off by 2050 and decline in a few areas (such as White, Willow, and West Black Lakes, Martin Beach, and the southeastern portion of Sabine Lake). Bald eagle populations are expected to increase in the southern White Lake area.

Furbearers, rabbits, and deer are expected to increase in Cameron Creole, remain steady in some areas (especially those areas under salinity control), and decline in others. American alligator populations are presently increasing, but are expected to level off by 2050. In the Sabine area, waterfowl, seabird, and shorebird populations are projected to decline generally in those areas currently experiencing the greatest land loss.

4.7.1.6 Invasive Mammalian Species

Destruction of coastal wetlands by invasive mammalian species, such as the feral hog and especially nutria, would likely continue into the future. Institutional recognition, such as the Louisiana Coast wide Nutria Control Program, will also likely continue to help address the problems caused by these animals.

4.7.2 Restoration Opportunities - Direct Impacts

Direct adverse impacts to wildlife would primarily result from those activities, which would directly harm, displace, or disturb wildlife. Direct adverse impacts to wildlife resources would primarily result from construction activities associated with the various features of each plan. Some wildlife species could be temporarily displaced from an area as disturbance from construction activities could result in unfavorable conditions for nesting, foraging, and/or other activities. However, most species would move to an area with more favorable conditions and return after construction is completed. In some instances, permanent displacement may occur with the construction of permanent project features (e.g., diversion structures).

RO1 (deltaic processes): Most wildlife species, and invasive species would directly benefit from the marsh creation features associated with RO1.

RO2 (geomorphic structure): Marsh creation of coastal wetland habitats and restoration of geomorphic structures throughout all subprovinces would have an overall positive effect on wildlife resources as well as invasive species.

TSP: Marsh creation of coastal wetland habitats and restoration of geomorphic structures throughout all subprovinces would have the greatest overall positive effect on wildlife resources, including invasive species of any restoration opportunity.

4.7.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Indirect impacts to wildlife resources resulting from RO1 would include the creation, restoration, and protection of wetland habitats utilized by those species for nesting, rearing of young, resting, and foraging activities. An increase in wetland acreage (compared to the future without-project conditions) would provide nesting, brood-rearing, and foraging habitat for resident avian species. Migratory avian species would also benefit from RO1 as important stopover habitat would be protected for neotropical migrants and wintering habitat would be created/protected for waterfowl. Game mammals and furbearers would also benefit from the increase in wetland types (i.e., swamp, fresh, and intermediate marsh) favored by the majority of those species. Reptiles and amphibians, which prefer fresher wetland types,

would also benefit from the projected increase in wetland acres. The invasive nutria would also likely benefit.

RO2 (geomorphic structure): Indirect impacts would be similar to RO1 except, important stopover habitat for migratory avian species would be created, restored, and/or protected; in addition, wintering habitat would be created/protected for waterfowl. The invasive nutria would principally benefit from beneficial use and marsh creation.

TSP: Indirect impacts would be a synergistic result over and above the additive combination of indirect impacts and benefits of RO1 and RO2.

4.7.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Historically, before human intervention, populations of birds, mammals, reptiles, and amphibians responded to natural population regulating mechanisms. However, recent historic and existing conditions within the study area (i.e., loss of coastal wetland habitats) have resulted in population declines for wildlife resources and that trend is expected to continue under the future without-project. Over the project life, RO1 would result in an increase of wetland acres compared to the future without-project (see section 4.6 Vegetation Resources). When combined with CWPPRA and other restoration authorities, RO1 would have an even greater impact on wildlife resources, as those programs would work synergistically to improve habitat conditions for wildlife populations across the coast. Continental populations of migratory avian species, such as neotropical songbirds and waterfowl, could improve as critical migratory habitat is restored, protected, and enhanced. Although unlikely to impact their populations on a continental scale, game animals, furbearers, reptiles, amphibians, and invasive species (especially the nutria) would also benefit from the cumulative effects of RO1 and other restoration programs.

RO2 (geomorphic structure): Cumulative impacts would be similar to RO1 except, migratory avian species would also benefit from RO1 as important stopover habitat would be protected for neotropical migrants and wintering habitat would be created/protected for waterfowl; the invasive nutria would likely only benefit from beneficial use of dredged material and marsh creation restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination impacts and benefits of RO1 and RO2. Efforts to control invasive species would be necessary.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis

4.8 PLANKTON RESOURCES

4.8.1 Future Without-Project Conditions - The No Action Alternative

Plankton populations respond to changes in environmental conditions. In particular, changes in salinity and nutrients can result in changes in abundance and community structure. In the future, population growth in Louisiana would be likely to result in greater nutrient flux to coastal waterbodies, via an increase in sewerage discharges. However, improvements in sewerage collection and treatment could offset this trend and reduce nutrient flux. Increased development would tend to increase storm water runoff, and application of fertilizers could increase over time as well, thus increasing the nutrient load on coastal waterbodies.

Increased nutrient concentrations would cause further deterioration of water quality in eutrophic lakes and bays, at times resulting in algal blooms, some of which would be noxious. Blooms are often characterized by a shift in community structure towards dominance by one or several species. Existing freshwater diversion projects introduce Mississippi River water into coastal waterbodies. This river water is generally high in nutrients, and some of the receiving areas are already eutrophic. To date, algal blooms resulting in hypoxic conditions have not been observed in response to diversions, but diversion projects such as Caernarvon and Davis Pond have not been used to their capacity except for pulses in Caernarvon.

It is unknown whether flows in the 8,000 to 10,000 cfs range in warm weather months would result in noxious blooms of blue-green algae, but there is likely some upper limit to the assimilation of nutrients into estuarine waters, beyond which blooms would occur. The river water is also cool, turbid, and would improve flushing rates in receiving waters; factors that would tend to reduce the occurrence of blooms. Future changes in the operation of existing diversion projects may occur. Increased flows would shift the plankton community, displacing the marine species in favor of the freshwater species.

4.8.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): The introduction of river water into estuarine systems can have dramatic short-term impacts on plankton populations in adjacent coastal waters (Hawes and Perry 1978). Hence, introduction of fresh river water flows from proposed diversions (reintroductions) would be expected to change plankton abundance and species composition. Changes in plankton species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the plankton community, displacing marine species in favor of fresher and more estuarine, euryhaline species.

RO2 (geomorphic structure): There would only be short-term minor adverse impacts to plankton populations during actual construction activities of restoration features due to increases in turbidity, low dissolved oxygen and introduction of dredged sediments into shallow open water areas. There would be long-term loss of shallow water habitats due to marsh creation and other land building activities. However, there is an over-abundance of shallow open water habitat available for use by plankton.

TSP: Direct impacts would be a combination of RO1 and RO2 effects.

4.8.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to plankton populations would primarily result from long-term and far field effects of freshwater and sediment diversions, salinity control structures, and project-induced changes to the tidal prism such as closure of barrier passes during restoration of barrier systems.

RO1 (deltaic processes): River water is cool, turbid, and would improve flushing rates in receiving waters; factors that would tend to reduce the occurrence of algal blooms. River water contains higher concentrations of nutrients, which would contribute to increased plankton populations. It is unknown whether proposed diversion (reintroduction) flows would result in noxious blooms of blue-green algae, but there is likely some upper limit to the assimilation of nutrients into estuarine waters, beyond which blooms would occur. To date, algal blooms resulting in hypoxic conditions have not been observed in response to diversions (reintroductions) projects at Caernarvon and Davis Pond. However, these structures have not been used to their capacity, except for occasional pulses at Caernarvon. Adaptive management in the operation of existing and proposed diversions (reintroductions) is recommended.

RO2 (geomorphic structure): There would be a long-term loss of shallow water habitats available for plankton populations due to marsh creation and other land building activities. However, there is an over-abundance of shallow open water habitat available for use by plankton.

TSP: Indirect impacts would be a combination of RO1 and RO2 effects.

4.8.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to plankton resources systems would primarily be related to the incremental impact of all past, present, and future actions effecting plankton resources such as existing freshwater diversions (e.g., Caernarvon, Davis Pond, West Bay, etc.); those diversions currently in planning or construction (e.g., Maurepas, etc); and similar actions.

RO1 (deltaic processes): In the Deltaic Plain, freshwater diversions would likely result in species switching from saline-dominant to more freshwater-dominant plankton species assemblages.

RO2 (geomorphic structure): The cumulative impacts would be negligible because there would be no diversions with this restoration opportunity.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.9 BENTHIC RESOURCES

4.9.1 Future Without-Project Conditions - The No Action Alternative

The species richness (variety of organisms) of the benthic community typically declines as one progresses from ocean waters, upstream into lower salinities, and often reaches a minimum between 4 and 6 ppt (Day et al., 1989). Hence, it is expected that increases in benthic community species diversity would continue as land loss continues across the Louisiana coast.

Day et al., (1993) indicate the preferences of some major groups of benthic organisms:

- suspension feeding organisms tend to favor firmer (sandier) substrates than do deposit feeders;
- interstitial meiofauna inhabit sandy areas;
- burrowing meiofauna inhabit silt mud; and
- some benthic organisms require high levels of organic matter.

Intertidal and shallow subtidal environments are generally more environmentally variable and stressful than deeper water. However, specific composition and distribution of the benthic community in any given area would be a function of the response of individual species to the changing characteristics of such factors as salinity regime, sediment characteristics, oxygen levels, detritus, desiccation, extreme ranges in temperatures, dissolved oxygen, and current velocity.

4.9.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Proposed diversions (reintroductions) and marsh creation would destroy existing benthic communities at the proposed constructions sites. In addition, introduction of river water into estuarine systems can have dramatic short-term impacts on benthic populations in adjacent coastal waters. Introduction of fresh river water flows from proposed diversions (reintroductions) would be expected to change benthic abundance, species composition, and species distribution. Changes in benthic species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the benthic plankton community, displacing marine species in favor of fresher and more estuarine, euryhaline species.

RO2 (geomorphic structure): Direct impacts caused by temporary loss of benthic community at borrow sites. Construction of geomorphic features would destroy benthos at placement sites.

TSP: Direct impacts would be a combination of RO1 and RO2 effects.

4.9.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to benthic resources would primarily result from long-term and far field effects of freshwater and sediment diversions, salinity control structures.

RO1 (deltaic processes): Species richness of benthic communities is usually greater in higher salinity waters (Day et al., 1989). Freshwater diversions (reintroductions) would likely reduce benthic species richness as greater volumes of freshwater are pushed deeper into estuarine basins. Intertidal and shallow subtidal environments are generally more environmentally variable and stressful than deeper water. Hence, shallow intertidal and subtidal habitat created by river diversions (reintroductions) would likely reduce the quality of existing saline benthic habitats and convert them to more-freshwater type habitats.

RO2 (geomorphic structure): Suspended sediments would cause short-term disturbance to sensitive benthic animals; smothering of benthos due to resettlement of suspended sediments; depletion of oxygen would also cause temporary disturbance, and possible loss to some benthos.

TSP: Indirect impacts would be a combination of RO1 and RO2 effects.

4.9.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to benthic resources would primarily be the incremental impact of all past, present and future actions effecting benthic resources such as existing freshwater diversions (e.g., Caernarvon, Davis Pond, West Bay, etc.); and those diversions currently under construction or in planning (e.g., Maurepas, etc); and similar actions.

RO1 (deltaic processes): Cumulative impacts would be the replacement of existing saline benthic habitats across the coast with fresher benthic habitats as proposed river diversions (reintroductions) are constructed.

RO2 (geomorphic structure): Cumulative impacts would be short-term disturbance to sensitive benthic animals due to construction of restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.10 FISHERIES RESOURCES

4.10.1 Future Without-Project Conditions - The No Action Alternative

Habitat Use modules, as described in appendix C "Hydrodynamic and Ecological Modeling", were developed to determine impacts of fish and wildlife resources in the study area, but were not used in the analysis of fisheries resources for this DPEIS. The Habitat Use modules are being refined and may be useful in the analysis of fisheries impacts in the near future. In addition to prediction from the Coast 2050, Habitat Switching and Land-Building models were used to assess changes in fisheries habitat. Those modules predict marsh type changes and marsh loss and gain. The analysis for fisheries future without action conditions and future with

alternative conditions relied on predictions of marsh habitat changes, and consideration of seasonal habitat changes (e.g., freshwater discharge, salinity, and temperature variation).

Direct impacts to fisheries may result from events such as hypoxia, but are expected to be smaller in comparison to indirect impacts. Indirect impacts to fisheries may result from the expected continuation of land loss and further loss of habitat supportive of estuarine and marine fishery species. In the short-term, land loss and predicted sea level changes are likely to increase open water habitats available to marine species, except in the active deltas of the Atchafalaya and Mississippi Rivers; and areas otherwise influenced by river flow, such as, the Caernarvon and Davis Pond Freshwater Diversions, and to a lesser extent, Pointe a la Hache and Naomi Siphons. In the long-term, as open water replaces wetland habitat and the extent of marsh to water interface begins to decrease, fishery productivity is likely to decline (Minello et al., 1994; Rozas et al., 1993). This may already be happening in the Barataria and Terrebonne estuaries. Browder et al., (1989) predicted that brown shrimp catches in Barataria, Timbalier, and Terrebonne Basins would peak around the year 2000 and may fall to zero within 52 to 105 years.

Other considerations on the impact to fisheries are predator/prey relationships; water quality, salinity, and temperature; harvest rates; wetland development activities (dredge/fill); habitat conversion (e.g., wetland to upland); and access blockages. Habitat suitability, population size, and harvest rates influence the future condition of fisheries. Habitat suitability for fisheries varies by species, and depends on different water quality and substrate types.

Along with indirect effects of no action on fisheries, restoration efforts in the state (e.g., CWPPRA) have aided fisheries habitat, and are likely to continue. Economic interest in fisheries and interest in Louisiana as a fishery resource for the Nation has increased significantly. The increase is expected to continue, leading to changes in fishing technology, fishing pressure, and fishing regulations in order to maintain sustainable commercial fisheries. It is likely that construction of levees, water control structures, and hurricane protection features will continue and/or increase as coastal residents protect themselves and their property from hurricane damage and flooding. All of these structures alter water flow, potentially block fisheries access, and may directly convert habitat supportive of fishery species to unsupportive areas.

Although fisheries productivity has remained high, as Louisiana has experienced tremendous marsh loss, this level of productivity may be unsustainable. As marsh loss occurs, a maximum marsh to water interface (i.e., edge) is reached (Browder 1985). A decline in this interface will follow if marsh loss continues and the overall value of the area as fisheries habitat will decrease (Minello et al., 2003). Because fishery productivity has been related to the extent of the marsh to water interface (Faller 1979, Dow 1985, Zimmerman et al., 1984), it is reasonable to expect fishery productivity to decline as the amount of this interface decreases.

As marsh and optimal habitat continue to erode, it is anticipated that oyster resources will experience a decline in the long-term. Although the conversion of marsh into open water will likely provide temporary new oyster habitat, the quality of this habitat is expected to decrease as populations become stressed by increased saltwater intrusion, predation, and lack of adequate shelter resulting from marsh erosion. Once buffered by interior and barrier wetlands, oyster reefs will be exposed directly to the gulf as surrounding marshes erode. This is likely to increase

damages to reefs related to storm events. For example, following Hurricane Andrew in 1992, many oyster farmers requested Federal relief for decimated oyster beds.

4.10.2 Restoration Opportunities - Direct Impacts

The project area supports one of the most productive fisheries in the Nation. However, it is believed that with no action, sharp declines in fisheries productivity are likely (Minello et al., 1994, Rozas et al., 1993). Impacts to fisheries resulting from the implementation of each plan will vary depending on the features included in the selected plan, species-specific habitat, prey, and spawning requirements, and current conditions in the Deltaic and Chenier Plain estuaries.

Some considerations, such as the impacts resulting from beneficial use of dredged material/marsh creation, are common across all plans. Impacts to fisheries as a result of freshwater diversions, dredging, beneficial use/marsh creation, salinity control, shoreline protection, and barrier island restoration are summarized in **table 4-4**. Long-term beneficial effects are likely to result from the preservation of marsh in each plan.

RO1 (deltaic processes): Direct impacts to fisheries would likely include entrapment in structures or behind cofferdams during construction of project features; mortality due to burial or sudden salinity changes; injury or mortality due to increased turbidity (e.g., gill abrasion, clogging of feeding apparatus); modified behavior, and displacement due to changing environmental conditions. Sessile and slow moving aquatic invertebrates may be disturbed by dredging and covered over by dredged material. Dredging and disposal activities, and the resultant increased turbidity, would temporarily displace mobile fishery organisms, but these species should return after disposal activities are completed.

Table 4-4. Items of consideration in the impact analysis of restoration opportunities on fisheries resources.	
Past, Present & Future Actions	Habitat restoration projects continue, economic interests increasing, restrictions on fishing and fishing gear continue or are increased, natural habitat declines (e.g., subsidence and sea level changes), and structural blockages to habitat are increased.
Essential Fish Habitat (EFH)	Essential Fish Habitat (EFH) is defined as “those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity.” Because impacts to EFH will impact fisheries species, alterations in EFH are listed below for each of the plans. In coastal Louisiana, EFH are the waters and substrates consisting of marine and estuarine (tidally-influenced) habitats (e.g., marsh); submerged aquatic vegetation; sand, mud and shell water bottoms, and water column. Coastal marsh loss is of particular concern in Louisiana, because the marshes are the most extensive in the nation and are believed to be largely responsible for the high production of estuarine-dependent species in the north-central Gulf of Mexico.
Freshwater Diversions (reintroductions)	Direct impacts to fisheries resulting from freshwater diversions include entrapment in structures or behind cofferdams during construction of project features; mortality due to burial or sudden salinity changes; injury or mortality due to increased turbidity (e.g., gill abrasion, clogging of feeding apparatus); modified behavior, and short-term displacement. Indirectly, fisheries may be displaced to offshore areas. Displacement is related to the timing and volume of freshwater input proposed. These projects prevent the loss of marsh, and generally improve conditions for subaquatic vegetation (SAV) and other highly productive forms of EFH. As a result, project areas can maintain most of their current ability to support GMFMC-managed species (such as white shrimp, brown shrimp, and red drum), as well as the estuarine-dependent species (such as spotted seatrout, gulf menhaden, striped mullet, and blue crab) that are preyed upon by other GMFMC-managed species (such as mackerels, red drum, snappers, and groupers) and highly migratory species (such as billfish and sharks). Potential increases in submerged aquatics will increase the habitat required for juveniles to escape predation and therefore increase quality and habitat.
Dredging	These projects, or project components, would negatively impact benthic organisms and benthic feeders in the borrow and disposal areas. Sessile and slow-moving aquatic invertebrates would be disturbed by the dredge or buried by the dredged material. Dredging and disposal activities and the resultant increased turbidity would temporarily displace other fisheries, but these species are expected to return after dredging and disposal activities are completed. Impacts include smothering of non-mobile benthic organisms in dredged material deposition sites and increased turbidity in waters near the construction sites.

American Oyster

Diversions (reintroductions) proposed in the upper hydrologic basins of the project area should not affect oyster populations, which were not historically, nor are presently, located in that area. The middle and lower basin diversions (reintroductions), and marsh creation sites could result in direct impacts through sedimentation onto oyster populations located closest to the proposed features. In addition to sedimentation, oyster populations within the influence area could be

subjected to over-freshening, which can increase mortality, affect reproduction, and affect spat settlement. Mortality is anticipated to occur on oyster beds where dredged disposal is directly placed. Localized benefits to oyster resources in the middle and lower basins in the deltaic plain may result from the proposed plan in areas that are currently too saline to sustain oysters. The extent of these impacts is dependent in part upon natural variations within basins, and the size, location, and operation of the diversion structures. Oyster surveys should be conducted to determine the spatial, temporal and cumulative impacts to private and public oyster resources in the affected environment. These surveys could enhance management decisions regarding operation of proposed structures.

RO2 (geomorphic structure): Compared to other plans, this plan depends less on diversions (reintroductions) of Mississippi River water (i.e., no new diversions are proposed) and more on marsh creation, barrier island restoration, and shoreline protection. Direct impacts to fisheries would likely include mortality due to burial; injury or mortality due to increased turbidity (e.g., gill abrasion, clogging of feeding apparatus); and short-term displacement associated with dredging and shoreline protection activities. Sessile and slow moving aquatic invertebrates would be covered over by dredged material. Dredging and disposal activities, and the resultant increased turbidity, would temporarily displace fishery organisms, but these species should return after disposal activities are completed.

American Oyster

Few direct impacts to oyster resources in addition to those described for sessile and slow moving organisms mention above are anticipated.

TSP: This plan depends on a combination of marsh creation, barrier island restoration, and diversions (reintroductions) of Mississippi River water. Direct impacts would include those discussed for RO1 and RO2.

American Oyster

Direct impacts would include those discussed for RO1 and RO2.

4.10.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Expected declines in fishery productivity may be reduced through the implementation of this plan, and the long-term sustainability of a productive fishery would be more likely than in the future without-project conditions. Indirect benefits to fisheries should result from increased productivity, land building, and area of marsh and submerged aquatic vegetation (SAV) habitats that are supportive of freshwater, estuarine, and marine fishery species. Subsidence and predicted sea level rise would be less likely to increase open water habitats.

Overall, this plan should benefit marine fishery resources in the Deltaic Plain and have minimal benefits to fishery resources in the Chenier Plain. Freshwater diversions can affect salinities in the project area significantly. Salinity is a fundamental environmental factor, because all organisms are 80 to 90 percent water, and internal salt concentrations must be maintained within a critical range. Each species, or life stage within a species, is adapted to a particular external

environment. Most estuarine-dependent organisms can tolerate a wider range of external salinities than either freshwater or marine species.

Multiple diversions into single hydrologic basins have the potential to significantly freshen large areas within and possibly the entire basin. Less fresh water tolerant species, such as brown shrimp and spotted seatrout, may be displaced from areas near diversions or entire hydrologic basins. The extent of this impact is dependent upon the diversion structures, location, size, and operation. Species, such as gulf menhaden, blue crab, white shrimp, and, red drum, that commonly utilize low to medium salinity areas, and SAV habitats would likely benefit from this plan. Fresh water fishery species, such as crawfish, catfish, largemouth bass and other sunfish, should benefit from implementation of this plan. This plan would indirectly impact species that are connected in the food chain to any directly affected species. Freshwater inflow is an important component of circulation and flushing processes in estuaries that assists in the transportation of planktonic organisms, nutrients, and detritus to the Gulf of Mexico. This would help support the aquatic food web of marine fishery species. Depending on size and operation of the structures, freshwater inflows can regulate salinity fluctuations and maintain a diversity of habitat types within the estuary, while improving marsh productivity. Inflows of sediment and nutrients create and maintain wetlands, which provide food and cover to juvenile fish, shrimp, crabs, oysters, and other biota. Transportation of beneficial sediments and nutrients to the estuary, and flushing of metabolic waste products from living organisms through the estuary, are other benefits of freshwater inflows. However, freshwater diversions (reintroductions) affect water quality in ways that could disrupt the nursery functions of an estuary by affecting food and habitat availability. Some fishery species would be impacted by anticipated decreases in salinity and water temperature, and increased turbidity associated with some RO1 restoration features.

American Oyster

Indirect impacts to oysters may result from a decrease in productivity due to sedimentation and over-freshening. The decrease in productivity could increase the vulnerability of oyster populations to seasonal stresses, storm events, and predation. Continued sedimentation and over-freshening could reduce the ability of oyster populations located in influence areas to recover, which could result in permanent loss of oyster resources while the structures are operating. Some oyster populations located outside the over-freshening areas could benefit from the plan as saline waters become more estuarine. The extent of these impacts is partly dependent upon natural variations within waterbodies, and the size, location and operation of the diversion structures. Oyster surveys and modeling where appropriate should be conducted to determine the spatial, temporal and cumulative impacts to private and public oyster resources in the affected environment. These surveys could enhance management decisions regarding operation of proposed structures.

RO2 (geomorphic structure): Compared to other plans, RO2 depends less on diversions (reintroductions) of Mississippi River water (i.e., no new diversions are proposed) and more on direct marsh and barrier island creation. Therefore, RO2 would have less impact in terms of habitat changes than other plans. RO2 will have less impact on those species, such as brown shrimp and spotted seatrout, which prefer more saline conditions than other estuarine-dependent species.

American Oyster

Few impacts to oyster resources are anticipated.

TSP: Indirect impacts would include those discussed for RO1 and RO2.

4.10.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. **Table 4-4** describes items considered in the impact analysis of restoration opportunities on fisheries resources. **Table 4-5** compares direct, indirect and cumulative impacts of the restoration opportunities on fisheries resources.

RO1 (deltaic processes): Restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) have aided fisheries habitat and are likely to continue to do so. Economic interest in fisheries, and interest in Louisiana as a fishery resource for the nation, has increased significantly in the recent past. This increase is expected to continue and lead to changes in fishing technology, fishing pressure, and fishing regulations, in order to maintain sustainable commercial fisheries. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, are likely to continue and/or increase, as coastal residents protect themselves and their property from hurricane damage and flooding. With this plan there should be an overall benefit to fisheries compared to the future with no action.

American Oyster

This plan may adversely impact growing conditions within a large area of oyster grounds, due primarily to numerous and/or large-scale freshwater diversions (reintroductions). The diversions (reintroductions) would have the potential to reduce salinities within receiving areas to levels, which are lethal to oysters across large areas of water bottom. As previously stated, this is partly dependent upon natural variations within waterbodies; the size, location, and operation of the diversion structures; and the proximity of oyster grounds to the diversions (reintroductions). In addition to over-freshening, this plan could adversely impact oysters as a result of sedimentation and the disposal of dredged sediments. Each of these actions could bury oysters or clog filters through which they feed. Sedimentation impacts could be more localized than freshwater impacts, which could reduce the aerial extent of damage to oysters located near marsh creation sites.

Table 4-5. Direct, indirect and cumulative impact of restoration opportunities on fisheries resources.					
Plans Components		Fisheries Resources			Essential Fish Habitat (EFH)
		Direct Impacts	Indirect Impacts	Cumulative Impacts	
ROI	Diversions=12, +3 diversions w/o structural impacts/Marsh creation= 1 Salinity/Water control= 2 Shoreline Protection= 0 Barrier Island Restoration= 0	Minor impacts due to entrapment during construction of diversions. Possible adverse impacts to benthic organisms as a result of marsh creation, sediment delivery, and dedicated dredging features.	Diversity of habitat increased and productivity maintained compared to no action. Displacement of some species and habitat preservation from the 38,000-110,000 cfs freshwater introductions. Habitat preservation from salinity control components of the Terrebonne marsh restoration opportunity.	In the LCA, a long-term increase in fishery productivity would be expected and a shift in species composition from those generally more tolerant of higher salinities to those generally more tolerant of lower salinities. Multiple diversions into single hydrologic basins have the potential to significantly freshen large areas within and possibly the entire basin. A decrease would be expected in production of species, such as brown shrimp and speckled trout, in areas most influenced by freshwater diversions (reintroductions). The U.S. would benefit by maintaining the productivity and diversity of marine fisheries.	This plan would preserve some highly productive categories of EFH that would be expected to be lost in the without-project conditions.
	Diversions= 0 Dredging= 0 Beneficial Use/Marsh creation= 2 Salinity/Water control= 0 Shoreline Protection= 4 Barrier Island Restoration= 2	Possible adverse benthic impacts as a result of marsh creation, beneficial use, shoreline protection, and barrier island features.	Habitat preservation from the barrier island restoration, marsh creation, shoreline protection, salinity control, and beneficial use.	Although this plan would help preserve some of the habitat and fishery productivity expected to be lost with no action within the LCA, it is unlikely that impacts would be measurable for the U.S.	This plan would preserve some highly productive categories of EFH that would be expected to be lost in the without-project conditions in isolated areas of the LCA. This preservation is not expected to be sustainable.
	Diversions= 8 +3 diversions w/o structural impacts Beneficial Use/Marsh creation= 3 Salinity/Water control = 2 Shoreline Protection= 2 Barrier Island Restoration= 2	Minor impacts due to entrapment during construction of diversions. Possible adverse impacts to benthic organisms as a result of marsh creation, barrier island restoration, and shoreline protection and sediment delivery measures.	Displacement and habitat preservation from the 34,000-90,000 cfs freshwater introductions. Diversity of habitat increased and productivity maintained compared to no action. Habitat preservation from barrier island, marsh creation, salinity control and shoreline protection projects.	In the LCA, a long-term increase in fishery productivity would be expected and a shift in species composition from those generally more tolerant of higher salinities to those generally more tolerant of lower salinities. Multiple diversions into single hydrologic basins have the potential to significantly freshen large areas within and possibly the entire basin. A decrease would be expected in production of species, such as brown shrimp and speckled trout, in areas most influenced by freshwater diversions (reintroductions). The U.S. would benefit by maintaining the productivity and diversity of marine fisheries.	Of the near term opportunities, this plan best preserves some highly productive categories of EFH that would be expected to be lost in the without-project conditions.

Although significant negative impacts are foreseeable within the influence areas of diversions (reintroductions) and sediment placement, localized benefits to oysters may be achieved, as estuarine conditions are created in areas previously too saline to support oyster production. Oyster surveys should be conducted to determine the spatial, temporal, and cumulative impacts to private and public oyster resources in the affected environment.

Louisiana has a far more extensive and productive oyster lease program than any other state in the United States. Providing more than 50 percent of the Nation's oysters, any project that adversely impacts oyster resources in Louisiana would impact nationwide oyster harvest, in addition to reducing the contribution of this industry to the local, state and national economy. Although in the long-term oyster populations are anticipated to benefit from large-scale coastal restoration, significant impacts could affect the industry for the foreseeable future.

RO2 (geomorphic structure): Restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) have aided fisheries habitat and are likely to continue to do so. Economic interest in fisheries, and interest in Louisiana as a fishery resource for the nation, has increased significantly in the recent past. This increase is expected to continue, and lead to changes in fishing technology, fishing pressure, and fishing regulations, in order to maintain sustainable commercial fisheries. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, are likely to continue and/or increase as coastal residents protect themselves and their property from hurricane damage and flooding. Although this plan would help preserve some of the habitat and fishery productivity expected to be lost with no action within the LCA, it is unlikely that impacts would be measurable for the U.S.

American Oyster

Few impacts to oyster resources are anticipated.

TSP: Cumulative impacts would include those discussed for RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.11 ESSENTIAL FISH HABITAT (EFH)

Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". In coastal Louisiana, those waters and substrate consist of estuarine (tidally-influenced) marsh, submerged aquatic vegetation (SAV), sand, mud and shell water bottoms, and estuarine water column; and marine sand, mud and shell water bottoms, beaches, and marine water column. Marsh loss is of particular concern in Louisiana, because the coastal marshes are the most extensive in the nation and are believed to be largely responsible for the high production of estuarine-dependent species in the north-central Gulf of Mexico. Therefore, impacts to EFH are largely described by consideration of impacts to marsh.

All plans are projected to preserve marsh. No plans are likely to result in a significant net loss or gain of EFH, as the plans mainly consist of converting one type of EFH to another (e.g., water bottoms and water column to marsh or SAV). The best plan for preserving EFH, and Federally managed species dependent on EFH, would increase marsh area the most, while maintaining the greatest diversity of marsh types and maintaining the most land-water interface. In general, the TSP and RO1 would protect categories of EFH for those Federally managed fishery species that are more freshwater tolerant or utilize SAV. In contrast, RO2 would protect categories of EFH for those Federally managed species that are more saltwater tolerant.

4.11.1 Future Without-Project Conditions - The No Action Alternative

Although previous restoration efforts in the LCA study area have helped maintain some categories of EFH, the cumulative impacts of land loss, conversion of habitats, sea level change, increased storm intensity, etc., are expected to lead to a net decrease in the habitat most supportive of estuarine and marine species (**table 3-4**). The direct losses of highly productive forms of EFH would lead to losses of shallow habitat, due to the exposed nature of the shallow open water bottoms that are being formed. Shallow waters are likely to become deep waters, and salinity gradients would be less estuarine, with a sharper distinction between saline and freshwater habitat, as coastal residents further attempt to protect self and property with levees, flood gates, and other water control structures.

It is believed that marsh loss that has been experienced to date, has increased this land/water interface, and increased fishery production. As land loss continues, it is believed that this interface would approach a maximum and begin to decline. This would, in turn, result in a decline in fishery production. In some areas, continued marsh loss is already resulting in the reduction of this interface.

Without implementation of the proposed action, the conversion of categories of EFH, such as inner marsh and marsh edge, to estuarine water column and mud, sand, or shell substrates is expected to continue. Over time, the no action alternative would result in a substantial decrease in the quality of EFH in the project area, and reduce the areas' ability to support Federally managed species.

The future without-project conditions would indirectly impact species that are linked in the food chain to directly affected species. Population reductions in directly affected species, such as brown shrimp and white shrimp, affect species dependant on shrimp for food. As marsh, barrier islands, and other EFH are directly lost, less protection would be available to remaining EFH. These areas would be more susceptible to storm, wind, and wave erosion. A decrease in species productiveness would result as populations are stressed by habitat displacement and reduction.

The effect of human activity, coupled with natural forces, has been substantial to EFH. Water quality degradation, invasive species introductions, storms, and fishing activities contribute to the negative impacts on EFH. Water quality regulations and coastal restoration efforts are believed to minimize some of these negative impacts to EFH. A reduction in suspended sediment load of the Mississippi River and mining of river sediments reduces the net supply available to coastal marshes, and contributes to their loss. Artificial levees confining the river

restrict river flow and reduce nourishment to barrier islands and delta building. Coupled with coastal degradation, subsidence, sea level change, shoreline erosion, and salt water intrusion the no action alternative substantially decreases the quality of EFH and the ability of the LCA study area to support Federally managed species.

4.11.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Some EFH would be lost due to the construction of water control features, diversion structures and ridges, where current forms of EFH (marsh, shallow open water, etc.) would be converted to uplands (i.e., non-tidally influenced ridges) or cement structures. However, the loss of this EFH is in isolated areas and generally would be offset by increases in high quality EFH (e.g., marsh) over much larger areas.

RO2 (geomorphic structure): Direct impacts would be similar to RO1.

TSP: Direct impacts would be similar to RO1.

4.11.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): RO1 is most likely to maintain the extent of marsh in the project area somewhat near present day conditions. These marshes are largely responsible for the high production of estuarine-dependent species in the north-central Gulf of Mexico. RO1 would improve the quality of some categories of EFH in some areas by re-establishing marsh, and protecting existing marsh. Categories of EFH, such as inner marsh and marsh edge, would not be converted to less productive forms of EFH (e.g., estuarine water column; and mud, sand, or shell substrates) as is expected with no action.

Some restoration features in RO1, such as Terrebonne marsh restoration would have some localized adverse impacts to some categories of EFH. However, RO1 would maintain most categories of EFH that have been designated for white shrimp, brown shrimp, red drum, gray snapper, lane snapper, Spanish mackerel, and bluefish. In addition, categories of EFH that are maintained or improved in quality would be supportive of estuarine-dependent species such as spotted seatrout, gulf menhaden, striped mullet, and blue crab. Some of these species serve as prey for other species managed under the Magnuson-Stevens Act (e.g., mackerels, red drum, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks). An increase in SAVs would increase the amount of habitat required for juveniles to escape predation and therefore increase quality of habitat. Freshwater diversion (reintroduction) flow regimes, where multiple diversions would be discharging into single hydrologic basins, would have to be coordinated to minimize the displacement of marine fishery organisms and to maintain a diversity of types of EFH.

RO1 would help to ensure the long-term sustainability of important habitats and the managed species that depend on those habitats during some stage in their life. Over time, RO1 would preserve some highly productive categories of EFH in the project area and therefore enhance the ability of the LCA study area to support Federally managed species.

As marsh, barrier islands, and other EFH are protected and enhanced, more protection would be provided to other categories of EFH as they would be less susceptible to storm, wind, and wave erosion.

RO2 (geomorphic structure): This plan consists of beneficial use/marsh creation, shoreline protection, and barrier island restoration activities. RO2 would prevent the conversion of some marsh expected to convert to less productive categories of EFH with no action. This conversion would be prevented in isolated areas of the LCA. RO2 is least likely to preserve the diversity and sustainable productivity of EFH.

TSP: Indirect impacts would include those discussed for RO1 and RO2.

4.11.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes cumulative impacts to significant resources; section 4.6 "Vegetation Resources," further describes impacts to vegetative forms of EFH (e.g., marsh and submersed aquatic vegetation). The effect of human activity, coupled with natural forces, has been substantial to EFH. Water quality degradation; invasive species introductions; storms; and a general reduction in marsh, barrier island and other habitats contribute to negative impacts on some categories of EFH (e.g., estuarine water column and marsh edge). Cumulative impacts of water quality regulations, land use regulations, and coastal restoration efforts are also discussed in section 4.10.4 Fisheries Resources. The TSP may reduce adverse impacts to some categories of EFH on a local or larger scale.

RO1 (deltaic processes): RO1 protects some categories of EFH (e.g., marsh edge, inner marsh, SAV, and beaches) and the ability of the LCA study area to support Federally managed species. RO1 would prevent the conversion of valuable inner marsh and marsh edge (i.e., categories of EFH for species such as brown shrimp, white shrimp, and red drum) to shallow open water and mud bottoms; decrease the vulnerability of and preserve some categories of EFH (e.g., SAV, beaches, mangroves, sand, silt, and mud bottoms) expected to be lost with no action. Freshwater diversion (reintroduction) flow regimes, where multiple diversions would be discharging into single hydrologic basins, would have to be coordinated to minimize the displacement of marine fishery organisms and to maintain a diversity of types of EFH.

RO2 (geomorphic structure): RO2 would preserve some categories EFH expected to be converted to less productive EFH with no action in isolated locations in the LCA. RO2 would create, restore, and/or preserve marsh, mangroves and beaches; all of which are categories of EFH of particular concern in Louisiana.

TSP: By increasing freshwater ,sediment, and nutrient input to the Deltaic Plain and reducing shoreline erosion, TSP would likely result in the least loss of coastal marshes in the LCA study area. Cumulative impacts would include those discussed for RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.12 THREATENED AND ENDANGERED SPECIES

Appendix B1 contains a Programmatic Biological Assessment of threatened and endangered species and the potential impacts of each plan in the final array of coast wide plans. Appendices B2 and B3 contains copies of coordination letters from the USFWS and NMFS, respectively, for the federally protected species under the jurisdiction of these agencies.

4.12.1 Future Without-Project Conditions - The No Action Alternative

Generally, continued coastal land loss and deterioration of critical coastal habitats, especially barrier shorelines/islands, is anticipated to impact all threatened and endangered species, which utilize coastal Louisiana. In particular, the brown pelican, bald eagle, piping plover, and all sea turtles would most likely be impacted the greatest as these species utilize the rapidly deteriorating barrier islands.

4.12.2 Restoration Opportunities - Direct Impacts

Direct impacts to threatened and endangered species would be generally confined to actual construction activities of any of the restoration features. For example, direct impacts would include the short-term, unavoidable disruption and displacement of species during construction activities; the potential incidental takes of sea turtles during dredge and placement operations during barrier system restoration. However, it is unlikely that any of the restoration opportunities would have any significant adverse, direct impacts to any threatened or endangered species. On the contrary, all restoration measures would provide a net increase of coastal wetland habitats used by these species.

RO1 (deltaic processes): There would be no direct impacts of RO1.

RO2 (geomorphic structure): Direct adverse impacts of the RO2 would be principally confined to actual construction activities of any of the restoration measures. This is most applicable to the following species:

- Piping plover critical habitat (beach habitat on barrier islands/shorelines). However, construction would be accomplished in reaches. These highly mobile birds would likely depart the restoration construction sites and return following completion restoration of the site. The District is presently coordinating with the USFWS regarding procedures and activity windows (time frames best suitable for construction to minimize disturbance to species).
- Sea turtles may be found on Louisiana coastal shorelines as well as in various coastal waters. The District has a long history of dredging and dealing with avoiding adverse impacts to sea turtles during dredging operations. In addition, we would maintain close coordination with NMFS to avoid potential impacts to sea turtles during dredging operations for restoration.
- Restoration of Brown Pelican nesting sites (islands) would be similar as described for Piping Plover critical habitats. The District has previously succeeded in restoring Brown

Pelican nesting habitat on Queen Bess Island as part of a joint effort between the CWPPRA and Barataria Channel maintenance dredging operations.

TSP: Direct impacts would be a synergistic similar to RO2.

4.12.3 Restoration Opportunities - Indirect Impacts

Indirect impacts to threatened and endangered species would primarily result from long-term and far field effects of restoration measures. For example, construction of restoration structures such as freshwater and sediment diversions would unavoidably alter existing salinity regimes and the vegetation patterns in some areas. Barrier system restoration would alter the configuration of barrier shorelines, headlands and islands. However, it is unlikely that any of the restoration opportunities would present significantly adverse indirect impacts to any threatened or endangered species. On the contrary, all restoration measures would likely provide a net increase of coastal wetland habitats used by these species.

RO1 (deltaic processes): There would be negligible, if any, indirect impacts with RO1.

RO2 (geomorphic structure): RO2 would provide an opportunity for the USFWS and NMFS to partially meet some of their objectives in the Restoration Plan for each of these respective species. In particular, it is likely that restoration of barrier shorelines, headlands and islands in Subprovince 2 and 3 would significantly reduce the local competition for these scarce and eroding barrier system habitat types and the resources they provide. Reduction in inter- and intra-species competition would positively impact barrier shoreline-dependent species such as the piping plover, brown pelican, and sea turtles.

TSP: Indirect impacts would be similar to RO2.

4.12.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP. Cumulative impacts to threatened and endangered species would primarily be related to the incremental impact of all past, present and future restoration activities, such as the beneficial use of dredged material for creation of bird islands; other Federal, state, local and private restoration actions such as CWPPRA restoration projects, Civil Works Section 204/1135 restoration projects, mitigation actions, and others.

RO1 (deltaic processes): There would be negligible, if any cumulative impacts with RO1.

RO2 (geomorphic structure): RO2 would significantly enhance, as well as create critical piping plover beach habitat in Subprovince 2 and 3. In addition, piping plovers, brown pelicans, and sea turtles would likely benefit from increases in available coastal wetland habitats, especially barrier shorelines, headlands, and islands. Most other species would not be impacted. Louisiana coast wide ecosystem restoration would help moderate impacts, especially to these three species, felt nationwide. However, these gains would be in contrast to continued loss of Subprovince 1

barrier system (e.g., Chandeleur Islands barrier system) as well as other gulf barrier system habitats.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.13 HYDROLOGY RESOURCES

4.13.1 Flow And Water Levels

4.13.1.1 Future Without-Project Conditions - The No Action Alternative

Should the trend of increased precipitation and period of climate warming continue, there would be continued increase in runoff, which may affect the total volume of fresh water in each subprovince, as well as flood peaks. Increased urbanization could also increase runoff, especially in Subprovince 1. Construction of oil and gas canals, flood protection works, navigation channels, coastal storms, increased vessel traffic, subsidence, and loss of vegetation due to saltwater intrusion can increase land loss, which in turn would affect hydrologic processes. Clearing forested land, conversion of forested wetlands to marshland and marshland to open water, and change in agriculture can also affect runoff. Coastal wetlands generally subside at a different rate than the adjacent ridges, which can increase the peak of the runoff. The loss of coastal wetlands would increase the influence of gulf waters during low to average runoff periods.

In Subprovince 3, the growth and development of the Atchafalaya deltas and the natural evolution of the Lower Atchafalaya River would increase water levels along the river, which in turn would increase the volume of water being conveyed by the GIWW to the east and west of the floodway.

4.13.1.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be minimal, provided measures are taken during construction to minimize impacts to drainage within the construction site and the designs of the features account for disruptions to existing flow patterns during the construction period.

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1, because there would be fewer restoration features.

TSP: Direct impacts would be similar to RO1.

4.13.1.3 **Restoration Opportunities - Indirect Impacts**

RO1 (deltaic processes): The major indirect impact would be the increase in the volume of water entering the receiving area for each diversion in each Subprovinces 1-3. The increase in volume of water entering the receiving area may result in changes to water levels. The magnitude of the water level change would depend on the location of the diversion, the magnitude of the diversion, the operational plan of the diversion structure, the physical characteristics of the receiving area, and what changes to the receiving area are incorporated into the design. All diversions would have the potential of increasing water levels over time over some part of the receiving area. Receiving areas with direct connections to the Gulf of Mexico, such as California Bay and Bayou Lamoque, would experience small changes to water levels unless the flow is channelized. In the receiving areas, over time, water levels may decrease in the proximate area of the diversion structure and increase in an area some distance away from the diversion structure. These impacts would be a result of the development of the distribution channels.

Depending on the operational plan for the diversion structures, this plan would decrease flow in the Mississippi River and could decrease flow year round. The decrease in flow in the river would increase the tidal prism entering the river system through Southwest Pass; tidal velocities in Southwest Pass may increase as a result. This plan would lower water levels on the Mississippi River below the diversions as a result of the reduced flow. Water levels would initially decrease, then rise over time. Deposition in the Mississippi River channel would result in an overall smaller river channel. As the channel gets smaller in response to the lower flow, water levels on the Mississippi River would rise and could ultimately be higher than existing water levels.

The volume of water moving through the passes of the Mississippi River would decrease, due to the additional number of diversions upriver. This may increase the amount of time the passes would be influenced by tidal exchange and may increase the tidal prism and the velocities associated with the tides.

Gapping dredged material disposal banks on the Amite River Diversion Canal would generally lower water levels along the river in the vicinity of the gaps, and improve the movement of water. During rainfall events, runoff would reach the river faster due to the presence of the gaps and may have the potential of reducing peak stages in the backswamp area. The shape of the Amite River hydrograph would be affected such that peak stages along the river may increase.

Water levels in Bayou Lafourche may increase, depending on channel size. The operation of the HNC Lock structure may increase water levels on the freshwater side of the structure; and, may increase the movement of gulf waters into other areas of the subprovince.

The altered hydrology may also increase the amount of time that it would take to evacuate storm surge waters that overtop levees or ridges, or runoff from significant rainfall events.

RO2 (geomorphic structure): Localized changes in water flows and sediment deposition patterns.

TSP: Indirect impacts would be similar to both RO1 and RO2 except: reef restoration in the Acadiana Bays may actually increase freshwater supply in the Vermilion Bay complex as the tidal exchange between East Cote Blanche Bay and Atchafalaya Bay/Gulf of Mexico would be reduced.

4.13.1.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Cumulative impacts would primarily be related to the incremental impact of all past, present and future actions effecting flow and water levels, such as existing freshwater diversions (e.g., Caernarvon, Davis Pond, West Bay, etc.); those diversions currently in planning or under construction (e.g., Maurepas, etc); and similar actions. Hence, the cumulative impacts of RO1 would be the incremental increase of freshwater supply, and the decrease of saltwater supply to the coastal area.

RO2 (geomorphic structure): Cumulative impacts would be similar, but less than RO1 in that water and sediment transport out of the system would decrease whereas in RO1 water and sediment flows into the system would increase.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.13.2 Sediment

4.13.2.1 Future Without-Project Conditions - The No Action Alternative

Changes in sediment transport and deposition patterns would reflect, in part, changes to flow conditions. In the future, where flow increases, suspended sediment load is likely to increase. Deposition would increase where the flow is conveyed. Should the trend of increased precipitation and period of climate warming continue, overall flow in the rivers and channels would remain above long-term averages, which in turn would result in maintaining an increased sediment load.

In the estuarine areas, changes in deposition patterns of silts and clays would be influenced by changes in velocity and salinity. In the areas where decreased velocity or increased salinity is predicted, deposition would increase. This could result in shifting deposition away from present depositional areas to these new depositional areas. Rivers north of Lake Pontchartrain would continue to convey sediments into Lake Pontchartrain, as would the Bonnet Carre Spillway.

With the exception of the new West Bay Diversion Channel, the existing subdelta channels of the Mississippi River would continue to be essentially ineffective in transporting sediment of sufficient quantity and type to offset subsidence. Existing freshwater diversions, such as

Caernarvon, would continue to provide some sediments to Subprovinces 1 and 2, and the effectiveness of these diversions should be essentially the same as today.

As the Atchafalaya River grows and develops, its ability to transport sediment would decrease. Sediment delivered to the Atchafalaya Bay would be lower than existing conditions, and the sediment would be finer. Additional sediment would be conveyed in the GIWW east and west of the Atchafalaya as flow increases.

4.13.2.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be minimal, provided that erosion protection measures would be utilized during construction to minimize impacts to drainage within the construction site; and, the design of the restoration features account for disruption to existing sedimentation patterns during the construction period. Dedicated dredging and beneficial use of dredged material could also disrupt sedimentation patterns. However, dedicated dredging and beneficial use would be conducted to meet all requirements of the Clean Water Act and the Inland Testing Manual.

RO2 (geomorphic structure): Direct impacts would be similar but less than RO1, because there would be fewer features.

TSP: Direct impacts would be similar to RO1.

4.13.2.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): All diversions in RO1 would increase the volume of sediment entering the receiving area. Such increases in the sediment volumes would depend on the location and physical characteristics of the diversions, as well as the time of year that the diversion would operate. The concentration of sediment in the Mississippi River would decrease in the downstream direction. Diversions, such as Whites Ditch, may convey a greater concentration of sediment than American/California Bay. Diversions located on the inside of bends would have deeper channels and would, therefore, divert a greater percentage of the river bedload material (sands).

Sediments entering the receiving area would have the potential to enhance or increase wetland acreage depending upon the following factors. The location and extent of sediment deposition, and the development of subaerial land would depend upon the physical characteristics of the receiving area and the type of sediment diverted. For the majority of diversions, sediment deposition could occur in wetlands, channels, lakes, and bays. Silts and clays would more likely be trapped in wetlands, and in those areas where salinity levels would be high enough to aggregate the clay particles. Sands would initially deposit in close proximity to the diversion site. However, as bifurcations developed, sand deposition would extend further away from the diversion site. Sand deposition would enhance subsidence. The presence of canal networks in the receiving area could confine sediments to the channels, increasing sediment deposition and reducing the effectiveness of the diversion in creating wetlands. Sediment deposition would

occur naturally in estuaries. However, many restoration features would likely alter the natural characteristics of estuaries, thereby affecting the locations for estuarine sediment deposition. For some of the features of RO1, channels would be constructed to direct sediment to targeted areas. As long as the transport capacity of such channels equal or exceed the volume of sediment to be transported, the sediments would be transported to the targeted area. However, it is likely that deposition may occur within these channels during part of the year. Also, depending on the head across the diversion structure, scour may actually occur downstream of the structure in the diversion outflow channel if velocities are high enough to scour the channel bed. Until the channel bed stabilizes, this would result in increased sediment delivery initially, but would also result in a flatter channel slope, which could affect the overall transport capacity of the outflow channel. Over time, the effectiveness of the outflow channel to convey sediments would decrease.

Diversions have the potential for increasing sediment deposition in the parent stream, downstream of the diversion. All diversions from the Mississippi River would have the potential of adversely affecting river navigation, as generally, sediment deposition would occur in the Mississippi River downstream of the diversion. The magnitude and extent of the sediment deposition, and its effect on navigation, would depend on the location and physical characteristics of the diversion.

RO1 would also show a minor potential for increased tidal effects in the Mississippi River passes; but, the location and extent of shoals would likely change from those presently observed.

Sediment deposition is likely in the Amite River Diversion Canal and Hope Canal if transport capacity is insufficient to convey sediments.

Sediment deposition would likely occur in Bayou Lafourche if the channel is not capable of transporting the additional sediment accompanying the increased flow. The operation of the HNC Lock structure may increase sediment deposition on the freshwater side of the structure and may increase scour due to increased tidal effects in channels on the gulf side. However, sediment from such scour would continue to deposit in the estuarine area. Sediment deposition may occur on the freshwater side of salinity control and freshwater introduction structures and the lock. In addition, scour may occur on the saltwater side or in the targeted area. Sediments may also be trapped in the targeted areas for freshwater introduction. In all subprovinces, sedimentation may increase in the existing channels and canals.

A well designed dedicated dredging program and beneficial use program for wetland restoration could minimize changes in sedimentation patterns as well as reduce sedimentation.

RO2 (geomorphic structure): Indirect impacts would be relocating estuarine sediment depocenters. Tidal prism modification would result in redistribution of sediments.

TSP: Indirect impacts would be similar to both RO1 and RO2, except: Reef restoration in the Acadiana Bays may actually increase freshwater supply in the Vermilion Bay complex as the tidal exchange between East Cote Blanche Bay and Atchafalaya Bay/Gulf of Mexico would be

reduced. This would affect the movement of water and sediment and influence deposition patterns in these areas.

4.13.2.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): The cumulative impact would be an increase in sediment supply to the coastal area available for land gain, an increase in sediment supply to forested wetlands, and a decrease in sediment supply to the Mississippi River. The diversions would decrease the volume of sediment, and decrease the sediment size in the Mississippi River available for diversions in the existing distributaries and in existing diversion projects, such as West Bay Sediment Diversion. Changes to sedimentation patterns by dedicated dredging and beneficial use would be in addition to ongoing navigation channel dredging and other dredging projects.

RO2 (geomorphic structure): Cumulative impacts would be similar, but less than RO1 in that sediment transport out of the system would decrease whereas in RO1 sediment supply into the system would increase.

Plan that Best Meets the Objective: Cumulative impacts would be similar but greater than both RO1 and RO2 as sediment input is increased and sediment output is decreased.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.13.3 Water Use And Supply

4.13.3.1 Future Without-Project Conditions - The No Action Alternative

In many coastal areas of southeastern Louisiana, fresh surface-water supplies would be limited to the Mississippi River, Atchafalaya River, and many of their distributaries. Because many of these water bodies are controlled by levees and their flows are maintained, it is doubtful that they would be affected by loss of surrounding wetlands. Because these water bodies are the major sources of freshwater in southeastern Louisiana, water use would be largely unaffected. However, Bayou Lafourche currently experiences periodic saltwater intrusion, primarily from Company Canal and the GIWW. Salinities in this bayou could increase, limiting freshwater supplies, if the surrounding area becomes saltier. Because fresh ground water is very limited or unavailable in most of the Bayou Lafourche area, the larger water users in this area, primarily industry and public supply, would have to treat the water for salinity or find new sources of freshwater.

In southwestern Louisiana, fresh surface and ground water are available in most coastal areas. However, surface water in some areas, such as the Calcasieu Basin, experience periodic saltwater inundation. Much of the water use in these areas is agricultural and farmers use ground water when surface supplies become salty. If surface-water salinities increased in coastal areas

because of wetland loss and erosion, it is likely that surface-water withdrawals would decrease and withdrawals from the Chicot aquifer system would increase.

4.13.3.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be minimal, provided that measures are taken during construction to minimize impacts to any existing water use in the area, and that the design of restoration features account for any disruptions of water use and supply during the construction period.

RO2 (geomorphic structure): Direct impacts would be similar to RO1.

TSP: Direct impacts would be similar to RO1.

4.12.3.3 Restoration Opportunities - Indirect Impacts

Both surface and ground water are used throughout the Deltaic Plain. It is unlikely that any of the restoration opportunities would have an impact on groundwater use, unless a restoration feature would provide a more effective source of fresh water. Most of the surface water used in the Deltaic Plain is withdrawn from the Mississippi River or its distributaries. Hence, any plan that would cause Mississippi River water levels to decline below pump intakes, or would induce saltwater intrusion up the river from the Gulf of Mexico, could affect freshwater use. The southernmost intakes along the Mississippi River that are currently used for public water supply are located in southern Plaquemines Parish. In the past, these freshwater intakes have been impacted by saltwater intrusion during prolonged periods of low river flows. Consequently, water from the Mississippi River should only be diverted when the river stage and discharge rate would be sufficient to minimize the potential for the reduction or loss of water supplies to downstream users. Otherwise, alternative sources of freshwater supply to these areas would be required.

RO1 (deltaic processes): Medium diversions of Mississippi River water may negatively impact freshwater supplies to downstream users of Mississippi River water. Increased flows into the receiving areas of Subprovinces 1 and 2, may enhance freshwater supply to users in those areas. Increased flows into Bayou Lafourche and the Terrebonne marshes would enhance freshwater supplies to users in those areas. Reduced saltwater intrusion into areas, such as Houma, may prolong freshwater supply to users in those areas.

RO2 (geomorphic structure): There would be negligible, if any, indirect impacts with RO2.

TSP: Indirect impacts would be similar to RO1.

4.13.3.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Cumulative impacts to water supply would primarily be related to the incremental impact of all past, present and future actions effecting water supply such as existing freshwater diversions (e.g., Caernarvon, Davis Pond, West Bay, etc.); those diversions currently in planning or construction (e.g., Maurepas, etc); and similar actions. Hence, for RO1, potential cumulative impacts would be the incremental decrease of freshwater supply in areas with water intakes along the Mississippi River (e.g., Point a la Hache, Port Sulfur, Venice, etc.). However, any potential adverse impacts to community and industrial water supplies would be mitigated. In Subprovince 3, it is anticipated that the proposed features would increase freshwater supply to areas such as Houma.

RO2 (geomorphic structure): There would be negligible, if any, cumulative impacts.

TSP: Cumulative impacts would be similar to RO1.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.13.4 Groundwater Resources

4.13.4.1 Future Without-Project Conditions - The No Action Alternative

In general, the impacts of wetland or coastline loss on ground-water conditions would be indirect, but could be significant in some areas. If wetland or coastline loss resulted in saltwater intrusion into current surface-water supplies, users would have to find alternate sources of water and could strain or deplete limited ground-water resources in some areas. In some aquifers, such as those in the Chicot aquifer system, increased pumping of ground water near the freshwater/saltwater interface could result in saltwater encroachment into freshwater portions of the aquifers.

4.13.4.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be unlikely. However, should the potential occur for direct impacts during construction, direct impacts could be minimal if appropriate measures would be taken during construction to minimize impacts to groundwater resources in the area, and if the designs of restoration features would account for any disruptions to ground water resources during the construction period.

RO2 (geomorphic structure): Direct impacts would be similar to RO1.

TSP: Direct impacts would be similar to RO1.

4.13.4.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): It is unlikely that RO1 would have any indirect effects on groundwater, unless groundwater withdrawals were to be reduced. However, implementation of RO1 would restore coastal wetlands that would potentially reduce saltwater intrusion into surface-water supplies and aquifers.

RO2 (geomorphic structure): Indirect impacts would be similar to RO1.

TSP: Indirect impacts would be similar to RO1.

4.13.4.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Cumulative impacts to groundwater would primarily be related to the incremental impact of all past, present and future actions effecting groundwater such as localized impacts to groundwater recharge. However, overall there would likely be no significant project-induced direct or indirect impacts to the aquifers throughout any subprovince; hence, no additional project-induced cumulative impacts would be expected.

RO2 (geomorphic structure): Cumulative impacts would be similar to RO1.

TSP: Cumulative impacts would be similar to RO1.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.14 WATER QUALITY RESOURCES

4.14.1 Future Without-Project Conditions - The No Action Alternative

Without the proposed actions of the LCA Plan, the coastal plain of Louisiana would still be affected by activities, natural and man-influenced, that would have both beneficial and detrimental effects to water quality conditions. Some of these activities include: other Federal, state, local, and private restoration efforts such as CWPPRA, USACE ecosystem restoration projects, and LDNR projects; state and local water quality management programs; national-level programs to address hypoxia in the northern Gulf of Mexico; the continued erosion/subsidence of the coast; oil and gas development; industrial, commercial, and residential development; and Federal, state, and municipal navigation and flood-damage reduction projects. The future quality of Louisiana's coastal waters depends on a responsible, watershed approach to managing these activities.

There are a number of present and future activities that would continue to occur without the proposed actions of the LCA Plan and would affect surface water quality conditions in the

coastal plain of Louisiana. The cumulative impact of these activities without the LCA Plan is discussed below.

Passage of the Clean Water Act in 1972 and the establishment of state and Federal environmental protection agencies resulted in water pollution control regulations, including:

- The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution. In 1997 the USEPA granted NPDES delegation to LDEQ, which is known as the Louisiana Pollutant Discharge Elimination System (LPDES).
- LDEQ's Nonpoint Source Pollution Program is continuing to implement watershed initiatives to address nonpoint source pollution sources such as agriculture, home sewage treatment, hydromodification, urban runoff, construction activities, and resource extraction.
- Total Maximum Daily Loads (TMDLs)-Section 303(d) of the CWA requires states to identify, list, and rank for development of TMDLs waters that do not meet applicable water quality standards after implementation of technology-based controls.
- Barataria-Terrebonne National Estuary Program (BTNEP) is a coalition of government, private, and commercial interests are active in collecting/publishing information, as well as educating the public to protect the Barataria and Terrebonne Basins.
- The USEPA-formed Hypoxia Task Force is leading a national task force to address hypoxia in the northern Gulf of Mexico, which is attributed to the excessive nutrients in the Mississippi – Atchafalaya River Basin. Refer to the Hypoxia section (section 3.16) of this document for further information.

The programs discussed above would continue to develop or remain in place with or without the proposed LCA Plan project features to ensure protection of Louisiana's public health and natural resources. Water quality conditions would likely improve with the programs in place. However, some activities that may potentially have negative effects on water quality would also continue to occur with or without the proposed LCA Plan. Other efforts that would probably improve water quality conditions would be the present and future Federal, state, local, and private ecosystem restoration projects.

- Industrial, commercial, and residential development along the coast. With this activity comes increased point and nonpoint source pollution from sources such as wastewater treatment facilities and urban runoff from new development. Also, activities associated with maintaining and improving navigation along the coast would continue to occur.
- Flood-damage reduction projects would continue to be planned, designed, and constructed especially in areas highly susceptible to flood damages due to hurricanes and tropical storm events. With these activities, more alterations to the hydrology of the coast would potentially occur leading to areas of degraded water quality. Some projects, such as the Morganza to the Gulf Hurricane Protection Project, are incorporating resource-sustainable design techniques that may aid in protecting significant resources such as surface waters of the state. Other projects, such as the Southeast Louisiana Urban Flood Control Project, are providing flood protection for a 10-year rainfall event. However, this is also increasing the flow of urban runoff that is diverted into Lake Pontchartrain and other surrounding water bodies without providing pollutant reduction measures as seen in

many storm water collection systems across the nation. Unfortunately, metro New Orleans' unique geographic setting does not allow for incorporating many pollutant reduction methods; however, the NPDES Storm Water Program and the continued development of TMDLs may require storm water professionals to find innovative methods, such as subsurface structural BMPs to drain the populated areas effectively while protecting the receiving water bodies as much as practicable. Adverse impacts to water quality by these Federal projects would be mitigated as legally mandated.

- The most notable activity that would continue to occur without the proposed LCA Plan is the ongoing erosion/subsidence or land-loss of the coastal areas. This would continue to unearth the expansive oil and gas infrastructure along the coast of Louisiana. This would be a precarious situation, especially during storm events and within navigable waterways. Exposed pipelines are vulnerable to navigation vessels striking them, which could lead to discharges into the Gulf of Mexico as well as other coastal, state water bodies. In the event of discharges, extensive ecological damage would probably occur. The owner(s) of the infrastructure could incur expensive fines and clean-up costs; and vessel operators could be seriously injured. There are other forms of infrastructure that could potentially be exposed due to coastal erosion including wastewater collection systems and other commercial-industry related systems.

4.14.2 Comparison Of Near-Term Restoration Opportunities

Generally, four water-quality conditions would change. However, the extent and magnitude of changes would vary with the particular plan. The four water quality conditions that would change include:

1. freshwater areas would increase;
2. salinities would remain similar to the future without-project conditions, except there would be a slight freshening in the following areas: Lake Borgne, northern portions of Breton Sound, Caminada Bay and nearby headland areas, and the upper reaches of Terrebonne and Timbalier Bays; and possibly in the Cote Blanche and Vermilion Bays complex;
3. sediments in the coastal zone would increase, with accompanying minor increases in trace metals associated with bed sediments; and
4. agrochemicals in the water would increase.

Introduction of river water into the estuarine systems would immediately change the water chemistry of receiving areas. Change may be beneficial or detrimental, depending on human perceptions and the water uses. For example, change from a less fresh to a fresher system could be perceived as beneficial to wetland nourishment, but detrimental to recreational use because of water color changes, and possible changes in fish species assemblages in the recreational area (see sections 4-10 "Fisheries Resources" and 4-17 "Recreation Resources"). Such changes in water chemistry would, therefore, mimic what occurred naturally and prior to the construction of levees.

Potential adverse chemical effects would include an increase or decrease in the methylation of mercury in bed sediments. However, it would be impossible to predict such increases or

decreases on anything but a site-specific basis. The potential for increase in mercury methylation could occur with the creation of new wetlands. Reintroduction of river water may increase the risk of conditions favorable to the causes of methylation.

Stabilization of salinity regimes would probably aid resource managers, commercial and recreational fisheries managers, and water users in making long-term decisions. Salinity could be either beneficial or detrimental, dependant on the user group. Salinity is not necessarily a pollutant in coastal waters. However, salt is highly toxic to rice in small amounts. Freshwater marshes are also sensitive to salinity levels, but varying seasonal levels of salinity have positive impacts on various commercial and recreational fisheries. On balance, the stabilization of salinities, or the relocation of saltier water zones gulfward, would benefit the majority of user groups throughout the LCA study area.

The reintroduction of sediments into the LCA study area would add some contaminants; these would include primarily trace metals and hydrophobic organic compounds. Trace metals and hydrophobic organic compounds such as pyrenes, hexachlorobenzene, and chlorinated hydrocarbons such as DDT, or its degradates, would absorb onto sediment particles or the organic coatings of sediment particles. The concentrations of such introduced compounds would not, in the best professional judgment of the USGS, be sufficient to exceed alert levels, or harm the environment.

The introduction of agrochemicals into the LCA study area from any of the restoration opportunities would be a management issue. The primary source of agrochemicals into the LCA study area would be from the corn belt of the mid-continental United States. Currently, agricultural chemicals, primarily herbicides and fertilizers, are being introduced into the LCA study area from the Mississippi/Atchafalaya River systems. These agricultural chemicals are then being further distributed into portions of the LCA study area via the GIWW and Bayou Lafourche. This input of agrochemicals, known as the spring flush, would be further distributed, to varying degrees, into the LCA study area by most of the freshwater introduction (diversions) measures that would be implemented under the various restoration opportunities. Adaptive management would be important in addressing this issue.

A water quality concern would be the herbicide atrazine, which is known to have endocrine disruption effects. The overall effect of this herbicide on the LCA study area would be unknown. Acute effects, such as marsh plant death would not occur, as evidenced by plants in the western Terrebonne marshes that are presently exposed to atrazine-laced water from the Atchafalaya River, with no readily obvious detrimental effects. The long-term effects of prolonged, but low-level, exposure to atrazine on both plants and animals, especially amphibians, are currently being investigated. The fertilizers in the spring flush would have both beneficial and detrimental effects, depending on site-specific areas. These nutrients are strongly implicated in the formation of the hypoxic zone off the mouth of the Mississippi River. A series of reintroductions may aid in reducing the size or duration of the gulf hypoxia, but it is also conceivable that the reintroductions would cause eutrophication of specific receiving waterbodies. Adaptive management would be key to addressing and controlling the effects, both expected and unexpected, of the nutrient pulses into various areas of the LCA.

4.14.3 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): River diversions could cause short- to long-term adverse impacts due to construction of restoration features including: increased total suspended sediments (TSS), turbidity, and organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures; and the possible release of oxygen depleting substances (organic or anaerobic sediments, especially with regard to dedicated dredging) as well as possibly increasing dissolved oxygen levels. Note that many of the direct impacts could also be indirect effect (see below). These impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs), the Inland Testing Manual protocols, and other applicable best management practices. See also section 4.14.1 "Comparison Of Near-Term Restoration Opportunities". Dedicated dredging (Myrtle Grove) would cause similar, but principally short-term impacts.

RO2 (geomorphic structure): Direct impacts would be similar to RO1, but related to marsh and barrier island land building, as this plan does not include any diversion features. The impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs), the Inland Testing Manual protocols, and other applicable best management practices. See also section 4.14.1 "Comparison Of Near-Term Restoration Opportunities."

TSP: Direct impacts would be a combination of RO1 and, to a lesser degree, RO2. See also section 4.14.1 "Comparison Of Near-Term Restoration Opportunities."

4.14.4 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Indirect effects of changes to water quality include: nutrient enrichment could possibly lead to increased algae blooms and freshwater tolerant aquatic organisms; increased turbidity could possibly lead to disruption of freshwater and marine organisms; decreased water temperatures; increased dissolved oxygen; freshwater areas would increase thereby providing additional habitats for aquatic organisms; salinities would stabilize or decrease; sediments in the coastal zone would increase, with accompanying minor increases in trace metals associated with bed sediments; and agrochemicals in the water would increase.

Reduction in salinities could improve water quality by reducing chelating potential of metals since total dissolved solids would be decreased. Also, reduction in salinity would decrease temperature variations in the fresher waters. It should be noted that there has been some discussion in the scientific community of the potential for negative effects due to Mississippi River diversions introducing excessive amounts of nutrients. However, monitoring through the adaptive management approach would be necessary to ensure proper assimilation is occurring in the receiving areas. Coordination with LDEQ, USEPA, and other stakeholders would be necessary to insure the applicable water bodies are protected. See also section 4.14.1 "Comparison Of Near-Term Restoration Opportunities."

RO2 (geomorphic structure): Marsh creation, barrier system restoration, and land-building features, such as dedicated dredging at Myrtle Grove, would primarily provide long-term improvement of water quality as wetlands serve as natural filters for improving water quality.

TSP: Indirect impacts would be similar, but somewhat less than the combination of RO1 and RO2 except: reef restoration in the Acadiana Bays may actually increase freshwater supply in the Vermilion Bay complex as the tidal exchange between East Cote Blanche Bay and Atchafalaya Bay/Gulf of Mexico would be reduced.

4.14.5 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

Implementing the LCA Plan, the coastal plain of Louisiana would be affected by other activities and programs that would have both cumulatively beneficial and detrimental effects on water quality conditions. Some of these past, present, and foreseeable future activities include state and local water quality management programs; national-level programs to address hypoxia in the northern Gulf of Mexico; oil and gas development; industrial, commercial and residential development; and federal, state and local navigation and flood-damage reduction projects.

The LCA Plan needs to consider these other activities, initiate an aggressive coordination plan with the stakeholders involved, and ensure all activities including the LCA Plan complement each other. This is critical to ensure the protection of Louisiana's coastal waters and the health of the public that utilizes these waters.

The Louisiana Department of Environmental Quality's (LDEQ) TMDL program is an example of a present program that would be affected by the implementation of some LCA project elements. Consequently, the incremental impact of both would affect water quality conditions. Section 303(d) of the CWA requires the state to identify, list, and rank for development of TMDLs waters that do not meet applicable water quality standards after implementation of technology-based controls.

This is a process whereby impaired or threatened water bodies and the pollutant(s) causing the impairment are systematically identified and a scientifically based strategy, a TMDL, is established to correct the impairment or eliminate the threat and restore the water body. An important factor in this process is the flow of water passing through the water body in question. With small, medium, and large diversions proposed for the LCA project in areas that have been disconnected from a main source of freshwater flow for years, it is critical for LDEQ to be aware of the proposed changes to the current hydrologic patterns. This would aid LDEQ in planning and implementation of TMDLs in water bodies to be impacted by the LCA Plan.

Other programs that could be affected by the LCA Plan and, simultaneously, cumulatively affect water quality conditions include LDEQ's LPDES (Louisiana Pollutant Discharge Elimination System) program, LDEQ's Nonpoint Source program, LDNR's Coastal Nonpoint Source program and others. With proper coordination and implementation of specific projects, the

activities and programs occurring along the coast may continue successfully in concert with the proposed LCA Plan.

The direct and indirect impacts discussed previously would cumulatively impact water quality conditions along with other coastal activities. The proposed diversions and fresh water introductions could independently elevate water quality constituents such as nutrients and sediment in receiving areas. Other activities such as development would potentially increase point and nonpoint source pollution in the same water bodies, therefore, causing a cumulative effect. However, continued state and federal programs tasked with regulating water quality impacts would benefit the same water bodies. It is not possible to quantify the effects to the water bodies from all of the coastal activities; however, during the project implementation phase testing and analysis would be conducted to better assess the effects due to the proposed LCA Plan.

RO1 (deltaic processes): Cumulative impacts to water quality would primarily be related to the incremental impact of all past, present, and future actions effecting water quality such as:

- increase in freshwater areas;
- stabilization or decrease in salinities;
- increase in sediment introduction to the coastal zone, with accompanying minor increases in trace metals associated with bed sediments;
- increase in agrochemicals in the water;
- increased total suspended sediments;
- increased turbidity;
- increased organic/nutrient enrichment of the water column;
- disturbance and release of possible contaminants;
- decrease in water temperatures along with less fluctuations;
- the possible release of oxygen depleting substances (organic or anaerobic sediments, especially with regard to dedicated dredging);
- less potential for chelating metals due to reduced total dissolved solids; and
- increased dissolved oxygen levels.

RO2 (geomorphic structure): Cumulative impacts would be similar, but to a much lesser extent than RO1.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis

4.15 GULF HYPOXIA

4.15.1 Future Without-Project Conditions - The No Action Alternative

The extent to which failing to implement the LCA Plan might affect the hypoxic zone is difficult to predict at this time. Largely, this depends on future climatic trends and the scale of other efforts to reduce nutrient loadings to the gulf from the Mississippi and Atchafalaya River Basins.

4.15.2 Restoration Opportunities - General

As part of the modeling effort for the LCA effort, a team of water quality experts from academia and the Federal government was assembled to help estimate the effects of the LCA plan on hypoxia in the northern Gulf of Mexico. This team developed a modeling approach to estimate the extent to which the various LCA features would reduce nitrogen entering the gulf. Given the programmatic nature of the LCA plan, it was understood that the results of this modeling effort would serve primarily to differentiate among alternatives with respect to their relative impacts on gulf hypoxia. It was further understood that accurate, quantitative estimates of the effects of particular restoration measures on gulf hypoxia would be developed at the project-level, when critical information regarding the location, size, and operation of such measures would be available.

Preliminary results of LCA water quality modeling efforts (see appendix C Hydrodynamic and Ecological Modeling), along with existing literature on the subject (Mitsch et al., 2001), suggest that large-scale river diversions could have the potential to contribute significantly to the national effort to reduce hypoxia in the northern gulf. Because the river diversion projects proposed in the LCA near term opportunities are relatively small, implementation of such projects would likely result in nutrient reductions that are small in comparison to total nutrient inputs from the Mississippi River to the gulf. Implementation of the near term plan would, however, provide an excellent opportunity to add to our understanding of the effectiveness of river diversions in reducing nutrient inputs from the Mississippi River to the gulf, while also further studying any potential adverse effects of such projects. The lessons learned from implementation of the river diversion projects in the near term plan could facilitate large-scale river diversion projects in the future, along with the potentially significant nutrient reductions such projects might provide.

As noted above, there remains some uncertainty regarding the efficacy of diversions with respect to nutrient removal, as well as the potential for adverse water quality impacts such as harmful algal blooms. Accurate assessments of nutrient retention and the potential for adverse effects depend on project-specific information regarding the size, location, and operation of the particular restoration measures. Accordingly, such assessments would be conducted during the development and review of specific projects.

4.15.3 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): This alternative would have no direct impacts on hypoxia in northern Gulf of Mexico.

RO2 (geomorphic structure): This alternative would have no direct impacts on hypoxia in northern Gulf of Mexico.

TSP: This alternative would have no direct impacts on hypoxia in northern Gulf of Mexico.

4.15.4 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): This alternative would likely result in a relatively small reduction in nutrients discharged into the northern Gulf of Mexico from the Mississippi River. Such a reduction in nutrients would have a minor positive effect on hypoxia in the northern Gulf of Mexico.

RO2 (geomorphic structure): This alternative would have no indirect impacts on hypoxia in northern Gulf of Mexico.

TSP: This alternative would likely result in a relatively small reduction in nutrients discharged into the northern Gulf of Mexico from the Mississippi River. Such a reduction in nutrients would have a minor positive effect on hypoxia in the northern Gulf of Mexico.

4.15.5 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): This alternative would likely result in a relatively small reduction in nutrients discharged into the northern Gulf of Mexico from the Mississippi River. Such a reduction in nutrients would have a minor positive effect on hypoxia in the northern Gulf of Mexico.

RO2 (geomorphic structure): This alternative would have no cumulative impacts on hypoxia in northern Gulf of Mexico.

TSP: This alternative would likely result in a relatively small reduction in nutrients discharged into the northern Gulf of Mexico from the Mississippi River. Such a reduction in nutrients would have a minor positive effect on hypoxia in the northern Gulf of Mexico.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.16 HISTORIC AND CULTURAL RESOURCES

4.16.1 Future Without-Project Conditions - The No Action Alternative

As inland marshes and barrier islands erode or subside, cultural resources existing on them could be exposed to elements or inundated, putting them at a greater risk of damage or destruction. Resources could also be adversely impacted over time by an increased risk of storm damage as

barrier islands and marshes continue to degrade. Cultural resources would continue to be affected as historical and archaeological sites are exposed to these forces.

In the future without-project scenario, the types of actions described above would have similar types of impacts to historic and cultural resources. Hence, any such actions would need to be examined on a project-by-project basis to avoid, minimize, reduce, and mitigate for impacts.

4.16.2 Restoration Opportunities - General

Addressing potential impacts to historic and cultural resources generally requires review of the National Register of Historic Places as well as cultural resources investigations on a project-by-project basis. The results of any investigations also need to be coordinated with the Louisiana's State Historic Preservation Officer (SHPO). Cultural resources evaluations are made on site-specific as well as project-specific information and plans. Maps indicating the location of cultural resources and cultural resources survey coverage are checked against the location of the proposed wetlands restoration projects. Cultural resource investigations may have been previously conducted in some portions of the LCA study area (such as for CWPPRA projects), which may have identified the locations of archeological and historical sites.

A cultural resources evaluation of each of the proposed wetlands restoration projects would need to be conducted as soon as plans and specification are known and well in advance of actual construction to avoid project delays. In some cases, project designs could destroy, damage, or obscure archeological sites by construction activities. These cultural resource investigations would identify any significant cultural resources, which may be at risk, and allow time for project design, changes to avoid adverse impacts. The site-specific nature of these resources demands this type of action. In some instances, the proposed action may actually help to preserve and protect cultural resources. Coastal lands are eroding rapidly and the protection of these lands by the various coastal restoration projects may protect sites in the long run by stopping or slowing down land erosion. Records from the Louisiana SHPO and the District would be reviewed to determine the locations of any previously recorded cultural resources and the extent of cultural resources survey coverage for each alternative.

In addition, preliminary archaeological and geologic data would be analyzed to determine the probability of encountering additional significant cultural resources. Cultural Resources surveys may be required to achieve compliance with the National Historic Preservation Act and NEPA.

4.16.3 Restoration Opportunities - Direct Impacts

Direct, indirect, and cumulative impacts to historic and cultural resources would be further developed on a project-by-project basis.

RO1 (deltaic processes): For the most part, three major types of actions predominate these proposed restoration measures. These are: 1) river diversions; 2) dredging of some type; and 3) construction of structures. River diversions and associated increased sedimentation may or may not have an adverse impact on historical and archaeological sites. Increased sedimentation may cause a direct impact on any site in the immediate area, while in some cases it could provide

sediment around an area acting as a buffer to further erosion. Depositing sediment on top of a known site can change the environment in which a site has survived. This may or may not be an adverse impact. An assessment would need to be made on a case-by-case basis for each restoration measure of this plan. Dredging may impact any prehistoric or historic shipwrecks in the area. Submerged cultural resources surveys are conducted in areas with a high probability of containing shipwrecks. Dredging can also impact prehistoric and historic cultural resources. Construction of erosion control devices, such as water control structures (i.e., weirs), dikes, or canal spoil banks can impact any prehistoric or historic site in the immediate impact area. In all cases these actions need to be examined on a project-by-project basis.

RO2 (geomorphic structure): Direct impacts to cultural resources could result in the area of immediate construction of restoration features.

TSP: Direct impacts to cultural resources could result in the area of immediate construction of structures, otherwise, same as RO1 and RO2.

4.16.4 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Indirect impacts to historic and cultural resources would be further developed on a project-by-project basis. Indirect impacts to cultural resources from project plans would include change in the conditions of the environment in which the cultural resource exist. Changes in the amount of water covering a cultural resource can change the environment in which the archeological, historic and cultural resources site has been preserved and cause increased decay. A change in the salinity in which the cultural resource exists destroys plant life around which the archeological, historic and cultural resources site exists and can cause increased erosion leading to the destruction of sites.

RO2 (geomorphic structure): Indirect impacts would be associated primarily with far field effects, such as the movement of barrier island building and shoreline protection sediments from initial restoration sites.

TSP: Indirect impacts would be the same as RO1 and RO2.

4.16.5 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Cumulative impacts to historic and cultural resources would be further developed on a project-by-project basis. A cultural resources evaluation of each of the proposed plans would be conducted. In some cases, project designs could destroy, damage, or obscure archeological, historic and cultural resources sites by construction activities. Cultural resource investigations would identify any significant cultural resources, which may be at risk and allow time for changes to the project designs to avoid adverse impacts. The site-specific nature of archeological, historic and cultural resources demands this type of action. In some instances the proposed action may actually help to preserve and protect cultural resources. Coastal lands are

eroding rapidly and the protection of these lands by this plan may protect archeological, historic, and cultural resources sites in the long run by stopping or slowing down land erosion.

RO2 (geomorphic structure): Cumulative impacts would be the same as RO1.

TSP: Cumulative impacts would be the same as RO1.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.17 RECREATION RESOURCES

4.17.1 Future Without-Project Conditions - The No Action Alternative

Much of the recreational activities occurring in Louisiana consist of hunting, fishing, and wildlife viewing. Recreational resources in the Louisiana coastal zone that would be most affected in the future without action are those related to loss of wetlands/marshes and habitat diversity. The general trend in wildlife abundance has been a decrease in wildlife numbers in areas experiencing high land loss and an increase in areas of freshwater input or land building due to restoration projects. Populations of migratory birds and other animals directly dependent on the marsh and swamp would decrease dramatically, an impact which would be felt in much of North America, where some of these species spend part of their life cycle. With the continued conversion of marsh to open water, much of the fishery productivity would be expected to peak followed by a sharp decline.

The coastal zone's changing environment would affect the recreational resources within that area. As existing freshwater wetland/marsh areas convert to salt-water marsh, then to open water, the recreational opportunities would change accordingly. Where populations of freshwater and/or saltwater species decline, so would the fishing (including crawfishing, crabbing, oyster harvesting) opportunities. In areas where the populations of game species flux, so would the hunting opportunities. As populations of migratory birds are affected, so would the opportunities for viewing.

Another major impact of land loss is the possible loss of facilities and infrastructure that support or are supported by recreational activities. Land loss can literally result in the loss of boat launches, parking areas, access roads, marinas, and supply shops. The loss of access features, such roads and boat launches, directly impacts an individual's ability to recreate in particular areas. The economic loss felt by marinas and other shops may be two-fold. One is potential loss of the actual facility or access to the facility, the other is change in opportunities. Habitat change and resulting changing recreation opportunities (i.e., fresh to marine) may for example severely impact a marina specializing in services to particular types of recreation (i.e., loss of freshwater opportunities).

4.17.1.1 Subprovince 1- Mississippi River, Lake Pontchartrain, and Breton Basins.

Without action, the recreation needs identified by the SCORP in this area may be expected to become greater, particularly for recreation opportunities dependent on estuarine species. Predicted land loss may impact access to recreation opportunities.

4.17.1.2 Subprovince 2- Barataria Basin

Without action, the recreation needs identified by the SCORP for this area may become greater. Land loss in general, particularly the potential loss of barrier islands and conversion of marsh to open water, may be the largest impact to recreation resources. Over time, conversion of marsh to open water may result in a decline of estuarine-dependent recreation. Access to marsh recreation opportunities, another identified need may be impacted by predicted land loss.

4.17.1.3 Subprovince 3- Teche/Vermilion, Atchafalaya, and Terrebonne Basins

Without action the recreation needs identified by the SCORP for this area may or may not be affected. Freshwater dependent opportunities in areas influenced by the active delta and freshwater from the Atchafalaya River should remain steady and possibly increase. In these same areas, saltwater opportunities may move further out into the gulf.

4.17.1.4 Subprovince 4- Calcasieu/Sabine and Mermentau Basins

Without action the recreation needs identified by the SCORP for this area may or may not be affected.

4.17.2 Restoration Opportunities - General

Without more specific project details and more detailed surveys and analysis, it is only possible to give general projections of the impacts of certain types of projects. Each restoration opportunity includes various project types. The impacts may vary greatly depending on location, size and scope of each particular project. Extensive recreation resources exist within the conceptual project footprint for all the alternatives. The possible impacts to these resources may or may not enhance recreational opportunities in the study area.

Recreation resources and opportunities are dependent upon many variables and many significant resources. Restoration activities may affect these resources in very different ways. In general, with the proposed restoration opportunities in the Louisiana coastal area, there would be a minor localized freshening over the future without-project action. Overall wildlife resources may benefit from all the proposed actions. Although to varying degrees, soil and vegetative resources are generally improved by proposed restoration opportunities. Introduction of freshwater may alter recreational opportunities immediately at and near diversion sites. The magnitude may vary relative to the size and location. For example, in the location of a freshwater diversion, freshwater opportunities may increase, while saltwater opportunities may be displaced. Where

marsh/wetland habitat is sustained, increased or improved, the associated recreational opportunities may be sustained and possibly increase, such as hunting, fishing and wildlife viewing. In areas with minimal salinity changes and where existing resources are sustained, it is expected that associated recreation activities may be sustained. In areas with reduced land loss and possible land building, valuable infrastructure, access roads and facilities, may be protected. Some immediate, short-term effects of restoration activities may have a negative impact on recreation opportunities, although over the course of study period the overall impact is expected to be more positive than future without-project conditions.

Recreational feature opportunities may develop as further detailed studies are conducted. If that should occur, the proper estates, e.g., fee, excluding minerals, would be acquired from private landowners for all areas including access areas.

4.17.2.1 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would primarily be displacement of recreationists due to construction of diversions and marsh creation.

RO2 (geomorphic structure): Direct impacts would primarily be displacement of recreationists due to construction of restoration features.

TSP: Direct impacts would be a combination of RO1 and RO2.

4.17.2.2 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): RO1 would have long-term localized minor changes to salinity regimes over future with no action. River diversions would increase vegetative growth (especially in fresh habitats) and promote land building in Subprovinces 1 to 3 thereby leading to increased recreation opportunities. The localized freshening of salinities (see section 4.3 "Salinity Regimes") and the increased acres of fresher habitats would result in a concomitant increase of freshwater recreation activities and a decrease of saltwater recreation activities in areas of freshwater reintroduction; as well as overall positive effect on most wildlife-dependent recreation activities.

Reducing land loss and possible land building may protect valuable infrastructure that supports certain recreation activities. Potentially this plan could therefore reduce loss of recreation-based infrastructure and access thereby decreasing expenses related to relocation, repair, or replacement. Economic impact on recreational fishing could be minimal because of species change.

Wildlife-dependent recreation activities may be maintained and possibly increase. Recreation activities dependent upon freshwater habitat would be maintained and possibly increase. Saltwater recreation activities may be displaced, somewhat, and therefore decrease, somewhat, in areas where freshwater is being introduced. The recreationist may have to travel further to enjoy recreation dependent on saltwater/marine habitat.

Possible protection of infrastructure may insure the access roads and facilities remain intact to support associated recreational activities.

There could be some economic impacts due to changing recreational activity patterns. The saltwater recreationist may incur minor additional expenses due to traveling further to reach saltwater opportunities. Marinas and facilities specializing in particular recreation activities may be somewhat affected by increased costs or possible loss of business related to lost/displaced recreation opportunities. Some facilities may adapt to changing recreational opportunities and clientele. Facilities able to adapt to changing demand may see positive economic impacts.

RO2 (geomorphic structure): Salinities would be similar to future without-project conditions. There would be long-term positive benefits to saltwater recreation activities primarily due to stabilization and restoration of barrier shorelines/islands.

TSP: Indirect impacts would be a combination of RO1 and RO2.

4.17.2.3 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Overall, RO1 would support and sustain a greater number of freshwater-based recreational opportunities, provide for a more stable freshwater-based recreation economy, and possibly increase the Louisiana recreation industry.

RO2 (geomorphic structure): Overall, RO2 would support and sustain a greater number of saltwater-based recreational opportunities, provide for a more stable saltwater-based recreation economy, and possibly increase the Louisiana recreation industry.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

Actual calculation of recreation impacts and benefits would require additional surveys based on specific project(s).

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.18 AESTHETICS

4.18.1 Future Without-Project Conditions - The No Action Alternative

Prominent visual changes to the Louisiana coastal area can best be determined by analyzing how lost land and changes in vegetation affects the visual distinctiveness of Louisiana's Scenic Byways. Scenic Byways display various combinations of archaeological, cultural, historic, natural, recreational, and scenic qualities that make them regionally significant. Therefore, the loss or diminishment of these qualities weakens the significance of the Scenic Byways. There

may also be future developmental actions that cause change in the natural environment along the Scenic Byways. The focus of this analysis is on how visual changes to the Scenic Byways, located in close proximity to the Gulf of Mexico, affects their significance.

4.18.1.1 Deltaic Plain

Louisiana State Highway 1 is a Louisiana Scenic Byway whose visual distinctiveness is characterized by the contrasting elements found at its southern-most portion. Homogeneous wetlands are viewed amongst meandering landforms, unnaturally straight canals, and the open water of the Gulf of Mexico. Land loss occurring along this Scenic Byway may result in diminished visual complexity as there is a relatively uniform view of open water along most of Highway 1.

4.18.1.2 Chenier Plain

Louisiana State Highway 82 is a National Scenic Byway whose visual distinctiveness is based on the contrasts caused by the diversity of elements present. Views are of homogeneous wetlands intermingling with meandering landforms, water, and linear elevated oak covered cheniers. Visual changes along this Scenic Byway would be caused by subtle wetland vegetative changes due to saltwater intrusion. These changes in wetland types would, most likely, not diminish the visual complexity surrounding Highway 82.

4.18.2 Restoration Opportunities - Direct Impacts

With implementation of the proposed action, work to develop each restoration opportunity may directly cause long-term and temporary impacts to the Louisiana Coastal Zone's visual resource base. Direct impacts to visual resources would primarily result from construction activities associated with the various features of each proposed restoration opportunity. Construction activities (e.g., diversion structures and associated canals) may permanently reduce or destroy the visual complexity (as defined in existing conditions) of scenic byways or undetermined visual resources (see existing conditions) that lie within the conceptual footprint of each restoration opportunity. Construction activity may also be visually distressful as heavy equipment's activity temporarily reduces visual experiences along the scenic byways and other undetermined visual resources.

Without more specific project details and more detailed surveys and analysis, it is only possible to give general projections of the direct impacts of certain types of projects. The impacts may vary greatly depending on location, size and scope of each particular project. What follows is a brief assessment in general terms of where construction activities may directly affect the visual complexity of the scenic byways.

RO1 (deltaic processes): Construction activities associated with the Covenant/Blind River and Hope Canal freshwater diversions may negatively impact undetermined visually complex areas. These diversions occur in proximity to the River Road Scenic Byway (LA Highway 641). Construction activities associated with the Donaldsonville, Pikes Peak and Edgard freshwater

diversions may also negatively impact undetermined visually complex areas. These diversions occur in proximity to the River Road Scenic Byway (LA Highway 405).

RO2 (geomorphic structure): The beneficial use of dredge material may result in visually interesting landforms that would benefit primary viewpoints found along Louisiana's Scenic Byways (see section 3.19 Aesthetics).

TSP: Direct impacts are similar to RO1 and RO2.

4.18.3 Restoration Opportunities - Indirect Impacts

With implementation of the proposed action, work to develop each alternative's plan may indirectly affect the Louisiana Coastal Zone's visual resource base. Indirect impacts to visual resources would primarily result from the possibility that newly developed—or restored—vegetative habitats (see Vegetative Resources) would enhance—or develop—visually complex areas alongside scenic byways or undetermined visual resources (see Existing Conditions).

Without more specific project details and more detailed surveys and analysis, it is only possible to give general projections of the indirect impacts of certain types of projects. The impacts may vary greatly depending on location, size and scope of each particular project. What follows is a brief assessment in general terms of where the conceptual footprint of each alternative's plan may indirectly affect the visual complexity of the scenic byways.

RO1 (deltaic processes): Indirect benefits to visual resources would primarily result from the possibility that newly developed—or restored—vegetative habitats would enhance—or develop—visually complex areas alongside scenic byways (River Road or Creole Nature Trail/Jean Lafitte) or undetermined visual resources.

RO2 (geomorphic structure): The beneficial use of dredge material may result in visually complex features as restored or enhanced vegetation is combined with constructed landforms. These newly formed visually complex features may benefit primary viewpoints found along Louisiana's Scenic Byways.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.18.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Human population growth, developmental actions, and other human activities have destroyed, enhanced, or preserved visual resources. Overall trends shown by models may be interpreted as reversing some of the damage caused by the above human actions and supporting visually complex aesthetic resources healthier than in future without-project. Cumulative impacts of maintaining visually appealing resources systems would further support tourism as one travels Louisiana's Scenic byways and remote areas of visual interest.

RO2 (geomorphic structure): Cumulative impacts are similar to RO1.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.19 AIR QUALITY

4.19.1 Future Without-Project Conditions - The No Action Alternative

Air quality would continue to be subject to institutional recognition and further regulations. However, air quality in the LCA study area would likely decline for the following reasons: continued population growth, further commercialization and industrialization, increased numbers of motor vehicles, and increased emissions from various engines. These impacts would be coupled with the continued loss of Louisiana coastal wetland vegetation that would no longer be available to remove gaseous pollutants. There would likely be associated increases in respiratory ailments (such as asthma) in the human populations. Air pollution would also have adverse aesthetic impacts on coastal views. These impacts would probably also have some impacts on the respiratory health of terrestrial wildlife, but information on such impacts is not readily available.

4.19.2 Restoration Opportunities - General

Generally, all restoration opportunities and the TSP would have similar direct, indirect and cumulative impacts on air quality.

Potential air quality impacts concerns would be accomplished on a project-by-project basis and in coordination with the LDEQ. As required by LAC 33:III.1405 B, an air quality applicability determination would be made for each specific project. This would include consideration of each separate project items of the proposed action for the category of general conformity in accordance with the Louisiana General Conformity, State Implementation Plan (SIP; LDEQ 1994). Generally, an air quality applicability determination would be calculated for each project within each plan based upon direct and indirect air emissions. See also section 3.20 "Air Quality."

4.19.3 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): There would be two primary direct impacts of RO1 on air quality:

1. Direct air emissions by machinery during actual construction activities. An air applicability determination analysis would be based upon direct emission for estimated construction hours. It has been our experience that total emissions for each work item separately (or even when all work items are summed) generally do not exceed the threshold limit applicable to volatile organic compounds (VOC) for parishes where the

most stringent requirement (50 tons per year in serious non-attainment parishes) is in effect, (see General Conformity, SIP, Section 1405 B.2), the VOC emissions for the proposed construction would be classified as *de minimus* and no further action would be required.

2. Indirect air emissions by engines used for operating equipment. Generally, since no other indirect Federal action, such as licensing or subsequent actions would likely be required or related to the restoration construction actions, it is likely that indirect emissions, if they would occur, would be negligible.

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1.

TSP: Direct impacts would be the combined effects of RO1 and RO2.

4.19.4 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Principal indirect impacts would be related to the potential improvement in air quality that increasing vegetated wetlands would provide. Improvement of air quality would provide positive benefits for humans suffering from health problems such as asthma and other respiratory problems.

Restoration of vegetated wetlands over the 50-year project life of RO1 would help to improve air quality by reducing particulates and gaseous air pollutants (see section 3.20 "Air Quality"). Studies of the effects of common wetland plants on removing or reducing air pollution in the coastal Louisiana area have yet to be done. However, it is reasonable to extrapolate from the findings of researchers such as David J. Nowak (personal communication, David J. Nowak, Project Leader, USDA Forest Service, Northeastern Research Station, 5 Moon Library, SUNY-CESF, Syracuse, New York) that the trees and vegetation in coastal Louisiana would improve air quality. Hence, over the 50-year project life of RO1, there would be a potential for the removal of tens of thousands of tons of air pollution at a potential value to society in the tens of millions of dollars. Detailed research into the potential air pollution removal capacity of the various wetland plants in coastal Louisiana, and the potential value to society (in Louisiana and nationwide) would be necessary before serious consideration is given to utilizing such information in any decision-making.

RO2 (geomorphic structure): Indirect impacts would generally be similar to RO1, but to a lesser degree.

TSP: Indirect impacts would be the combined effects of RO1 and RO2.

4.19.5 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Primary cumulative impacts would be the potential improvement of air quality due to the removal of air pollutants by vegetation; other cumulative impacts include the

cumulative effects of similar Federal, state, local, and private wetland restoration efforts that would also contribute to reduction of air pollution; as well as other technological efforts such as scrubbers on smoke stacks, more stringent emissions standards on motors, etc. From the cumulative impacts perspective, this potential improvement in air quality by LCA restoration efforts would be in contrast to continued air pollution by other sources.

RO2 (geomorphic structure): Cumulative impacts similar to RO1, but to a lesser degree.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.20 NOISE

4.20.1 Future Without-Project Conditions

Localized and temporary noise impacts would likely continue to affect the relatively few humans and animals in the remote coastal wetland areas. Potential noise impacts concerns may be expected for those human workers at oil and gas extraction sites; recreationists, and during any construction activities. Additional noise impacts would be associated with the villages, towns, and clusters of human habitations. Institutional recognition of noise, such as provided by the regulations for Occupational Noise Exposure (29 CFR Part 1910.95) under the Occupational Safety and Health Act of 1970, as amended, would continue.

4.20.2 Restoration Opportunities - General

Generally, addressing potential noise impacts concerns would be accomplished on a project-by-project basis using the following six step conceptual approach (after Canter 1996): Step 1—identification of noise impacts; Step 2—preparation of description of existing noise environment conditions; Step 3—procurement of relevant noise standards and/or guidelines; Step 4—impact prediction; Step 5—assessment of impact significance; Step 6—identification and incorporation of mitigation measures. A similar approach would be used for those projects that may require addressing potential vibration impacts.

Noise impacts would likely affect relatively few humans in the remote coastal wetland areas. Potential noise impacts concerns may be expected for those human workers at restoration construction sites. However, as provided by the regulations for Occupational Noise Exposure (29 CFR Part 1910.95) under the Occupational Safety and Health Act of 1970, as amended, when employees are subjected to sound exceeding those described under the Occupational Safety and Health Standards, feasible administrative or engineering controls shall be utilized via effective hearing conservation programs. Further, in accordance with the standards, if such controls fail to reduce sound levels within acceptable levels, personal protective equipment shall be provided and used to reduce sound levels.

It is anticipated that, in some instances, noise impacts may be an important issue for its potential effects on wildlife, such as disruption of normal breeding patterns and abandonment of nesting colonies. However, tolerance of unnatural disturbance varies among wildlife. Therefore, these issues shall be addressed by identifying the key species of concern and following feasible administrative and or engineering controls, determining and implementing appropriate buffer zones, and implementing construction “activity windows” i.e., project construction initiation and completion dates to minimize disturbance to nesting birds (see Martin and Lester, 1990). The District has utilized activity window restrictions with great success when restoring the endangered brown pelican-nesting habitat on Queen Bess Island in the Barataria Bay.

4.20.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Generally, all restoration opportunities would have only short-term, and minor, direct impacts on noise. Addressing potential noise impacts would be accomplished on a project-by-project basis. Any noise impacts would likely affect relatively few humans other than those employed at or near restoration construction sites due to the typically remote locations of such sites. When employees are subjected to sound exceeding those described under the Occupational Safety and Health Standards, feasible administrative or engineering controls shall be utilized via effective hearing conservation programs. Further, in accordance with these standards, if such controls fail to reduce sound levels within acceptable levels, personal protective equipment shall be provided and used to reduce sound levels.

In some instances, noise impacts may directly impact fish and wildlife species. These organisms would generally avoid the construction area. However, tolerance of unnatural disturbance varies among wildlife. Therefore these issues shall be addressed by identifying the key species of concern and following feasible administrative and or engineering controls, determining and implementing appropriate buffer zones, and implementing construction “activity windows” i.e., project construction initiation and completion dates to minimize disturbance to nesting birds (see Martin and Lester 1990).

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1.

TSP: Direct impacts would be the combination of RO1 and RO2.

4.20.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): It is anticipated that, in some instances, noise impacts may be an important issue for its potential indirect effects on wildlife, such as disruption of normal breeding patterns and abandonment of nesting colonies. However, tolerance of unnatural disturbance varies among wildlife. Therefore, these issues shall be addressed by identifying the key species of concern and following feasible administrative and or engineering controls, determining and implementing appropriate buffer zones, and implementing construction “activity windows” i.e., project construction initiation and completion dates to minimize disturbance to nesting birds (see Martin and Lester 1990). The District has utilized activity window restrictions with great success when restoring the endangered brown pelican-nesting habitat on Queen Bess Island in the Barataria Bay.

RO2 (geomorphic structure): Indirect impacts similar, but likely somewhat greater than RO1.

TSP: Indirect impacts would be the additive effects of both RO1 and RO2.

4.20.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): The cumulative impacts would principally be related to the potential short-term disruption of fish and wildlife species and similar impacts by other similar Federal, state, local and private restoration activities as well as other human-induced noise disruptions to these organisms.

RO2 (geomorphic structure): The cumulative impacts would be similar to RO1, but with somewhat greater potential impacts on those fish and wildlife species that utilize barrier system habitat.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.21 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

4.21.1 Future Without-Project Conditions - The No Action Alternative

Land loss is expected to increase and there would be further erosion along the Louisiana coast. There are a number of known HTRW sites of concern that may be directly impacted through coastal land loss. In addition to these known sites of concern, coastal erosion, and coastal flooding would impact a large number of unknown/unidentified HTRW sites of concern. These sites include, but are not limited to waste disposal facilities; landfills; open pits, ponds or lagoons for waste treatment or associated with oil and gas drilling activities; wastewater treatment facilities; and underground storage tanks. An extensive oil and gas industry along the Louisiana coast has created a large number of potential HTRW problems. Coastal erosion of oil and gas fields, and flooding of structures and facilities may exacerbate these problems. The exposure of pipelines and loss of protection for gas processing facilities from coastal erosion would likely increase risk of ruptured pipelines and accidental spills, and therefore, cause further damage to the environment.

4.21.2 Restoration Opportunities - Direct Impacts

Hazardous, Toxic, and Radioactive Waste (HTRW) impacts would be addressed on a project-by-project basis, via a Phase I Initial Site Assessment (ISA). A Phase I ISA is required for all USACE Civil Works Projects, to facilitate early identification and appropriate consideration of

potential HTRW problems (see section 3.21 "Hazardous, Toxic, and Radioactive Waste (HTRW)").

RO1 (deltaic processes): An HTRW Phase I ISA addressing potential direct impacts would be accomplished on a project-by-project basis. Any HTRW discovered during the ISA would be avoided to the maximum extent practicable, to minimize potential direct impacts.

RO2 (geomorphic structure): All restoration features would be investigated for potential HTRW; see RO1.

TSP: All restoration features would be investigated for potential HTRW; see RO1.

4.21.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): An HTRW Phase I ISA addressing potential indirect impacts would be accomplished on a project-by-project basis. Any HTRW discovered during the ISA would be avoided to the maximum extent practicable, to minimize potential indirect impacts.

RO2 (geomorphic structure): All restoration features would be investigated for potential HTRW; see RO1.

TSP: All restoration features would be investigated for potential HTRW; see RO1.

4.21.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): An HTRW Phase I ISA addressing potential cumulative impacts would be accomplished on a project-by-project basis. Primary cumulative impacts would be the avoidance or removal of hazardous and toxic waste through early identification. Discovery of previously unknown HTRW sites of concern would allow avoidance of contaminated areas or removal of hazardous materials prior to initiation of construction activities.

RO2 (geomorphic structure): All plans would be investigated for potential HTRW; see RO1.

TSP: All plans would be investigated for potential HTRW; see RO1.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22 SOCIO-ECONOMIC AND HUMAN RESOURCES

The purpose of this section is to review direct, indirect, and cumulative impacts on significant economic resources of each plan in the final array compared to taking no federal action.

Table 2-21 summarizes the comparison of restoration opportunities among significant environmental resources.

4.22.1 Population

4.22.1.1 Future Without-Project Conditions - The No Action Alternative

A slower growth rate has been projected by the Louisiana Population Data Center at Louisiana State University through the year 2020 and the District has extended this projection through the year 2050. Overall, the population of the 17-parish area is expected to grow at a compound annual growth rate of 0.42 percent during the next 50-year period. It is anticipated that this growth rate would occur with or without the LCA Plan in place. The exact location of the population growth would be influenced by many factors, including land availability, flood protection, and improvements to the transportation network. In the future without-project conditions scenario, the population in the coastal communities is expected to shift to the more northern portions of the coastal parishes.

4.22.1.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): The population shift further inland and to urban and suburban areas would be slower than in the future without project conditions. In addition, project implementation would change salinity levels in fisheries areas, causing some species to relocate. As a result, subsistence fishermen would potentially have to relocate to follow these resources. This would result in relocation costs and potential changes in community cohesion as existing communities are lost, and could result in employment shifts as some fishermen changed to other means of subsistence.

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1, due to fewer restoration features. However, there would likely be no relocations of subsistence fishermen associated with this restoration opportunity.

TSP: Direct impacts would be similar to RO1.

4.22.1.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Coastal population patterns should remain more intact than with the future without-project conditions.

RO2 (geomorphic structure): Indirect impacts would be similar but less than RO1, due to fewer restoration features.

TSP: Indirect impacts would be similar to RO1.

4.22.1.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): The population shift away from the coastal areas would be slower than the future without-project conditions.

RO2 (geomorphic structure): Cumulative impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.2 Infrastructure

4.22.2.1 Future Without-Project Conditions - The No Action Alternative

The risk to the assets listed in **table 3-9** has not been defined sufficiently to allow for without project damage projections to be made. That type of effort would require that the areas be delineated to a level of precision that does not currently exist, as well as require that probabilities be assigned to each of the delineated area. Hence, this information is included in this report simply to show the reader the high value of the assets that would be impacted with either direct loss or increased damages as the coast continues to recede. However, given the current loss of coastal wetlands, it is highly likely that infrastructure would suffer increased damages since these wetlands provide storm surge protection.

4.22.2.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): RO1 would probably reduce the erosion, damage, and necessity for relocation, repair, or replacement to infrastructure nearest the coast, than with the future without-project conditions.

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Direct impacts would be similar to RO1 and RO2.

4.22.2.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): There would probably be less relocations of infrastructure than with the future without-project conditions.

RO2 (geomorphic structure): Indirect impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.22.2.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): There would be a reduced level of infrastructure damages and relocations than with the future without-project conditions.

RO2 (geomorphic structure): Cumulative impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.3 Employment and Income

4.22.3.1 Future Without-Project Conditions - The No Action Alternative

Slow growth in employment is expected to occur as the economy improves without the proposed LCA Plan in place. The prospects of income opportunities may decline as well in the rural areas if they experience continued depletion of their natural resources. Without the implementation of the LCA Plan, residents and businesses may decide to move further inland to avoid the effects of periodic hurricanes and tropical storms. Economic activity related to wetland resources would also be adversely affected by the depletion of these resources.

4.22.3.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): The loss of income and jobs would be slower than with the future without-project conditions.

RO2 (geomorphic structure): Direct impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Direct impacts would be similar to RO1 and RO2.

4.22.3.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Coastal jobs, property values, and population could be better protected than with the future without-project conditions.

RO2 (geomorphic structure): Indirect impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.22.3.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Continued population growth with less population out-migration in rural coastal areas is probable than with the future without-project conditions.

RO2 (geomorphic structure): Cumulative impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.4 Commercial Fisheries

4.22.4.1 Future Without-Project Conditions - The No Action Alternative

Concurrent with projected land loss there would be an increase in saltwater intrusion into some of the upper estuaries as barrier islands and marshes degrade. This would result in a shift in the populations of fishes and invertebrates, with more saline-dominated species replacing freshwater species in some areas. The band of intermediate salinity necessary for oyster production would likely narrow significantly, and essential fish habitat for many commercial fishery species would likewise decline, leading to a net loss in fisheries population size and diversity.

Wetland habitat losses would decrease the productivity of Louisiana's coastal fisheries. The seafood industry would likely suffer significant losses in employment as estuaries, which are necessary to produce shrimp, oysters, and other valuable species, erode. Job losses would occur in the areas reliant on fishing, harvesting, processing, and shipping of the seafood catch. Thus, changes in existing fisheries habitat caused by wetland loss, saltwater intrusion, and reduced salinity gradients would likely increase the risk of a decline in the supply of nationally distributed seafood products from Louisiana's coast.

The connections between coastal estuaries and offshore populations vary geographically. Approximately 32 percent of the commercial fish landings off the northeastern states depend upon estuaries during some life stage. The dependence figure jumps to 98 percent along the Gulf of Mexico, where marshes support menhaden and shrimp populations.

It is estimated that over 75 percent of Louisiana's commercially harvested fish and shellfish populations are dependant on these wetlands during at least some portion of their lifecycle. Wetland habitat losses would decrease the productivity of these fisheries. Marsh loss and associated habitat changes may have already affected blue crab populations. Moreover, menhaden depend upon the estuary for a critical stage in their life cycle.

The seafood industry would likely suffer significant losses in employment as resources, which are necessary to produce shrimp, oysters, and other valuable species (mainly estuaries) begin to erode. Job losses would occur in the areas of fishing, harvesting, processing, and shipping of seafood catch.

4.22.4.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be primarily related to construction of restoration features with minor adverse impacts due to entrapment during construction of diversions and as a result of marsh creation, sediment delivery, and dedicated dredging restoration features.

RO2 (geomorphic structure): Direct impacts would be primarily related to construction of restoration features such as marsh creation, sediment delivery, and dedicated dredging restoration features.

TSP: Direct impacts would be similar to RO1 and RO2.

4.22.4.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): could cause displacement of some species with resultant changes in fishing patterns, including location and species harvested compared to the future without-project conditions. Diversity of habitat increased and productivity maintained compared to future without-project. There would likely be habitat preservation for commercial fisheries species from salinity control components of the Terrebonne marsh restoration features.

RO2 (geomorphic structure): Habitat preservation from the barrier island restoration, marsh creation shoreline protection, salinity control, and beneficial use features.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.22.4.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Overall, the industry would be more stable than with the future without-project conditions. A long-term increase in fishery productivity would be expected and a shift in species composition from those generally more tolerant of higher salinities to those generally more tolerant of lower salinities. Multiple diversions into a single hydrologic basin have the potential to significantly freshen large areas within and possibly the entire basin. A decrease would be expected in production of commercially important species such as brown shrimp in areas influenced by freshwater diversions. The U. S. would benefit by maintaining the productivity and diversity of marine fisheries.

RO2 (geomorphic structure): This plan would help preserve some habitat and fishery productivity expected to be lost under the future without-project conditions. Impacts for the entire U.S. would probably not be measurable.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.5 Oyster Leases

4.22.5.1 Future Without-Project Conditions - The No Action Alternative

In the future with no action, saltwater intrusion would continue, except in areas where existing freshwater diversion projects are able to reverse that trend. Production from leases would be likely to decline gradually, as areas of suitable salinities move inland and begin to overlap with areas closed due to fecal coliform near sewerage sources in developed areas. At the same time, level or increased production would be likely to occur from leases in bands of intermediate distance from freshwater introduction, where salinities are favorable. Salinities could be stabilized by existing freshwater diversions in two of the most productive basins, the Breton Sound and Barataria Basins. Leases in these basins would be likely to continue current levels of productivity. As oyster production from leases decline, it would likely result in lower oyster supply, higher oyster prices, and loss of income and jobs in the oyster industry.

4.22.5.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): While each of the restoration opportunities may have direct impacts to oysters (such as marsh creation at Myrtle Grove), the impacts to the actual leases would be considered indirect, except in cases where existing leases would be acquired from the leaseholder as a project cost. Some oyster leases would be likely to be acquired from the leaseholder if the ability to harvest oysters from the lease would be adversely impacted by the proposed action.

RO2 (geomorphic structure): Direct impacts would be similar to RO1.

TSP: Direct impacts would be similar to RO1.

4.22.5.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Oyster leases would be negatively impacted in Subprovince 1, with salinities unfavorable for oyster survival likely to occur in much of the Breton Sound Basin, but slightly enhanced conditions for oyster growth and survival in the Pontchartrain Basin. In Subprovince 2, oyster leases would be negatively impacted by low salinities, although leases in some areas could maintain production. Lease productivity based on bedding of seed oysters from public grounds, could also be negatively impacted due to decreased seed availability from the Breton Sound Basin. Impacts to oyster leases in Subprovince 3 would be minimal overall, with some spatial shifts in production due to changes in hydrology and resultant changes in salinity. There are no oyster leases in Subprovince 4. Any negative impacts on oysters would result in lower oyster supply, higher oyster prices, loss of income and jobs.

RO2 (geomorphic structure): There would be minimal, localized impacts to oyster leases in areas where construction occurs, due primarily to increased turbidity and siltation caused by dredging and disposal activities.

TSP: Indirect impacts would be similar to RO1.

4.22.5.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Louisiana has a far more extensive and productive oyster lease program than any other state in the United States. Maryland, Texas, and Virginia have leasing programs, but none produces close to the amount of oysters produced from leases in Louisiana. Therefore, any project that adversely impacts oyster leases in Louisiana would impact nationwide oyster harvests from leases.

RO1 would be likely to adversely impact the growing conditions on a large acreage of leases, due primarily to the large-scale freshwater diversions. The diversions would have the potential to produce salinities that are lethal to oysters across large areas of waterbottoms. Existing freshwater diversion projects with capacities of approximately 8,000 to 12,800 cfs have been found to induce oyster mortality in some areas, but have enhanced oyster production overall. Approximately 9,200 acres of leases were acquired from the leaseholders by the state of Louisiana in anticipation of the impacts of the Davis Pond Freshwater Diversion Project, which has a capacity flow of 10,650 cfs. RO1 includes diversions of a combined capacity that could potentially result in the loss of production from a significant percentage of the total leased acreage in Louisiana. It is unknown whether increased harvest from other areas in Louisiana could offset this lost production. Any negative impact on oysters would result in lower oyster supply, higher oyster prices, loss of income and jobs.

RO2 (geomorphic structure): Cumulative impacts would be minimal with this alternative, affecting only a small percentage of active leases located near project sites.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.6 Oil, Gas, And Minerals

4.22.6.1 Future Without-Project Conditions - The No Action Alternative

Most of Louisiana's oil and gas production occurs in the LCA. This area is at an elevated risk due to the land loss and ecosystem degradation. Loss of wetland, marsh, and barrier islands presents a range of threats to inshore and offshore oil and gas infrastructure. Existing inshore

facilities are not designed to withstand excessive wind and wave actions, which would become more commonplace as existing marshes are lost or converted into open bays. In addition, erosion and the subsequent disappearance of barrier islands would allow gulf type swells from tropical storm events to travel further inland. The combination of these factors would increase the risk to inshore facilities. To address this risk, the oil and gas industry will be faced with the decision to invest in improvements in order to maintain production/transmission or conversely the closure and abandonment of infrastructure.

The offshore oil and gas industry in the coastal zone is an important component in meeting National energy requirements. Coastal land losses have, and will continue to have, a negative effect on the extensive pipeline network located in coastal areas. As the open water areas behind the barrier islands increase in size, the tidal exchange volumes and velocities increase in the tidal passes and channels. This action can lead to the scouring away of sediments atop buried pipelines, exposing the pipelines and increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions. Resulting production or transmission shortfalls may result in disruptions in the availability of crude oil or natural gas to a significant part of the U.S.

The impact to these nationally important resources would be felt in numerous ways depending upon location (i.e., whether onshore or offshore).

Onshore Facilities. In the year 2000, onshore production of oil accounted for 16 percent of statewide production and onshore production of natural gas accounted for approximately 26 percent of statewide production. Statewide production includes onshore, Louisiana state waters and Louisiana Outer Continental Shelf (OCS). Most of this onshore production of oil and gas occurs in the southern part of the state, in areas most at risk due to the degrading coastal landscape. Representatives in the oil and gas industry have indicated that these inshore facilities were not designed to accept wind and wave type forces that would be experienced in open bays or worse, gulf type swells. The owners of these facilities would therefore be faced with the decision of whether to protect these facilities from these types of forces or curtail the production. For the most part, these onshore facilities represent the older production facilities in the state and, absent significant reserves being discovered due to improved exploration techniques, are on the downside of their production. The major oil companies have recognized this trend, and many have already sold off these assets to independent operators who can operate these reserves more profitably since they operate at lower overhead levels. Even with lower cost factors, the expenses incurred in adapting these facilities from a relatively protected marsh-type environment to one where significant wave action would or could occur would probably force some of the operators to shut-in that production.

Offshore Facilities. The offshore oil and gas industry is becoming increasingly important to the national energy picture. The impact to this sector would not be to the structures themselves, but to the supply base that keeps them operating at peak efficiency and reliability. There are only a few supply bases serving the deepwater oil and gas industry in the state, with the largest one being Port Fourchon in Lafourche Parish, near the Gulf of Mexico. These bases provide not only the necessary supplies and maintenance services to the offshore platforms, but are also the “jumping-off” spot for the company employees that work on the platforms on rotating schedules.

If one of these important bases were severely impacted as a result of coastal degradation, such as increasing storm surges, the operational cost of this offshore production would go up significantly.

4.22.6.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): RO1 would provide protection to the refineries, wells, and other oil and gas producing facilities and equipment, and potentially avoid some of the costs of relocation.

RO2 (geomorphic structure): Direct impacts would be similar to RO1, however, restoration of the Caminada-Moreau Headland would provide increased level of protection to the LOOP facility and Port Fourchon.

TSP: Direct impacts would be similar to RO1 and RO2.

4.22.6.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Restoration features could reduce the necessity of relocation as well as protect jobs.

RO2 (geomorphic structure): Indirect impacts would be similar to RO1.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.22.6.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): There would be a potential for reduced damages to oil and gas producing facilities and equipment. Relocations would also be reduced.

RO2 (geomorphic structure): Cumulative impacts would be similar to RO1.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.7 Pipelines

4.22.7.1 Future Without-Project Conditions - The No Action Alternative

Coastal land losses have, and would continue to have, a significant negative effect on the extensive pipelines traversing coastal areas. These pipelines are used for bringing oil/gas onshore from the numerous production facilities offshore; transporting oil/gas from onshore

production facilities; and in some cases, large pipelines used for interstate transport of oil and gas. Louisiana's pipelines carry oil to refineries located in gulf coast, Midwestern, and Eastern Seaboard states and natural gas to consumers in most of the states east of the Mississippi River. As the open water areas behind the barrier islands increase in size due to coastal erosion, the tidal exchange volumes and velocities increase in the tidal passes and channels. In many instances, this has led to the scouring away of sediments atop these buried pipelines and in some cases, has undermined them. This action subjects these pipelines to increased risk of damage or failure due to anchor dragging or lack of structural stability. Shell Oil Company estimates that their costs related to crude oil releases from pipelines struck by vessels are in the range of \$10,000 to \$12,000 per barrel. Any impact to the price of crude oil or natural gas would ripple through the economy, since they are the preferred fuel for area power plants, cogeneration facilities, and a major feedstock for many types of industries.

4.22.7.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Diversions and marsh creation could be expected to increase protection for pipelines from potential damages from storms, wave action, boats, anchor dragging, and saltwater exposure.

RO2 (geomorphic structure): Direct impacts would be similar to RO1. Under RO2 barrier islands and shoreline protection can be expected to increase protection for pipelines from these potential damages.

TSP: Direct impacts would be a combination of RO1 and RO2.

4.22.7.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): The costs of repairing or relocating pipelines would be reduced.

RO2 (geomorphic structure): Indirect impacts would be similar to RO1.

TSP: Indirect impacts would be a combination of RO1 and RO2.

4.22.7.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): The potential risks of damage would be reduced, lessening the potential costs of repair or relocation.

RO2 (geomorphic structure): Cumulative impacts would be similar to RO1.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.8 Navigation

4.22.8.1 Future Without-Project Conditions - The No Action Alternative

A majority of Louisiana's navigable waterways would be adversely impacted without action as marshes and barrier islands that protect waterborne traffic on inland waterways continue to erode. As land adjacent to and connecting these waterways disappears, waterways currently protected would be exposed to wind, weather, and waves found in open bays and the Gulf of Mexico. Additionally, navigation channels that cross open bays may silt in more rapidly or begin to shoal in less predictable ways. The potential impacts to these waterways and the vessels that use them include increased maintenance costs (e.g., dredging), the necessity for higher horsepower vessels to counteract increased currents and wave forces, and increased risk of groundings, collisions or storm damage to vessels and cargo. Moreover, shoaling causes the thousands of tows that traverse this area annually to slow down, thereby increasing both the transit time and cost of transportation. Due to increased safety concerns, alternate methods of transportation may have to be taken by hazardous commodities now utilizing the GIWW. These impacts would have a corresponding effect on cargo rates, which would affect the local and national economies.

Continued coastal erosion in south Louisiana could also increase the risk of obstruction or closure of the lower Mississippi River to navigation because of siltation or the loss of channel due to hurricane damage. Any closure of the river would result in increased operating costs of the ships waiting to enter or leave port as well as possible higher costs for inventory, additional storage costs, commodity flow restrictions, etc. It is estimated that a 7-day closure of the lower Mississippi River Navigation Channel would result in a loss of approximately \$50 million, and a 14-day closure would result in a loss approximately \$200 million. These estimates only include increased operating costs of the ships waiting to enter or leave port. Additional costs would likely occur because of value of inventory, additional storage costs, commodity flow restrictions, etc (Waldemar Nelson and Company 2003).

All the ports and waterways noted in the previous sections have projected positive annual growth rates over the next 50 years. Estimated growth for cargo moving on the Mississippi River System is about 1 percent annually. This estimate was derived from the growth rates used in the Upper Mississippi River Illinois Waterway Navigation study. Growth rate estimates for the Louisiana GIWW is 0.78 percent (this is the mid-level estimate from a commodity forecast from the Calcasieu Lock Replacement study). Average annual growth for the activity associated with the rig fabrication and offshore service industry is 1.67 percent (this estimate comes from a forecast prepared for the Houma Navigation Canal Deepening study). Positive economic impacts associated with the navigation industry would continue over time in the without project case. Any environmentally negative impacts from navigation in the study would worsen over time without any projects in place.

4.22.8.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Repairs and improvements to the GIWW would result in positive direct impacts for navigation traffic. It could allow two-way traffic in areas that otherwise required one-way traffic, and transportation times could be reduced as a result of improved channel conditions. Both of these factors would result in lower transportation costs.

RO2 (geomorphic structure): There are expected to be MRGO environmental restoration measures that would have direct negative impacts to navigation traffic. Measures that create a closure, either permanent or moveable, could result in significant relocation costs as well as increased transportation costs.

TSP: The direct impacts to navigation related to MRGO restoration measures from this restoration opportunity are expected to be the same as those described in RO2. That is, structures that are proposed as MRGO restoration measures are expected to cause direct negative impacts to navigation. As in RO1, GIWW improvements are expected to produce positive direct impacts for navigation.

4.22.8.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): In Subprovince 1, assuming no changes to the Mississippi River current that require navigation aids, no indirect effect would be anticipated for navigation. However, it is possible that this restoration opportunity would result in decreased flow velocities, increases in maintenance dredging costs, and decreased channel size. The magnitude of impacts to navigation would need to be further investigated. Changes to the operation of the HNC Lock for environmental purposes are not expected to have a significant impact to navigation.

RO2 (geomorphic structure): There are not expected to be indirect impacts to navigation from this restoration opportunity.

TSP: Indirect impacts would be similar to RO1.

4.22.8.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): The cumulative effects of diversions are expected to increase the amount of and the cost of dredging to maintain existing channel depths. There could be some favorable indirect effects of individual diversions for certain river distances and in the short term as described in the previous section. However, in the long run, the cumulative effect of all of the diversions is expected to increase shoaling downstream resulting in greater net dredging costs to maintain existing channel depths.

RO2 (geomorphic structure): The negative impacts of the MRGO environmental restoration measures would have the following types of cumulative impacts on navigation traffic: measures

that create a closure, either permanent or moveable, could result in significant relocation costs as well as increased transportation costs over the LCA study area.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.9 Flood Control

4.22.9.1 Future Without-Project Conditions - The No Action Alternative

The continuing erosion of the Louisiana coastline has increased the potential for flood damages from the surges of hurricanes and tropical storms throughout southern Louisiana. Existing, future without-project damages, and future with-project damages were estimated for each of the subprovinces based on the stages associated with the 100-year storm event. Failure to maintain coastal wetlands would result in a significant level of increases in damages from storm surges that are currently reduced by coastal wetlands. There would also be damages to the levees themselves, which would require increased expenditures to raise, repair, and replace the hurricane protection levees.

4.22.9.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Marsh restoration can be expected to have negligible reduction in flood damages for those areas outside the protection levees.

RO2 (geomorphic structure): Barrier island restoration can be expected to have negligible reduction in flood damages for those areas outside the protection levees.

TSP: Direct impacts would be a combination of RO1 and RO2.

4.22.9.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Flood damage could be reduced, thereby reducing repair costs and possibly preventing relocations. Diversions could be expected to reduce storm surge and require less investment in flood protection infrastructure. Additional adverse effects could result from the Donaldsonville diversion. Flood stages could be increased due to sediment causing a smaller channel.

RO2 (geomorphic structure): barrier island rebuilding could be expected to reduce storm surge and require less investment in flood protection infrastructure.

TSP: Indirect impacts would be similar to RO1.

4.22.9.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): In addition to existing diversions Caernarvon and Davis Pond, the proposed LCA diversions could cumulatively be expected to reduce storm surge and require less investment in flood protection infrastructure. The proposed diversion in the Donaldsonville area and the small Bayou Lafourche reintroduction could cause localized flooding impacts this area. Flood stages could be increased due to sedimentation of the Bayou Lafourche channel.

RO2 (geomorphic structure): In addition to the existing CWPPRA barrier island rebuilding efforts, the LCA barrier island restoration could be expected to reduce storm surge and require less investment in flood protection infrastructure.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.10 Hurricane Protection Levees

4.22.10.1 Future Without-Project Conditions - The No Action Alternative

While the Lake Pontchartrain and Vicinity, LA and West Bank and Vicinity, LA projects provide significant protection against large hurricanes, they cannot protect against slow moving category 3 or higher strength storms. The remaining hurricane protection projects provide much lower levels of protection. In addition, the project area is experiencing high levels of coastal wetlands losses which is likely increasing the threat from hurricanes. Although coastal restoration projects have been constructed, these have not significantly reversed the current rate of losses. Additional projects have been proposed and are under study to address the coastal land loss problem, but these projects have not moved beyond the study stage at this time. Other conditions that could impact hurricane protection issues are sea level change and apparent subsidence issues. These issues were not considered in the feasibility studies that resulted in the authorization of some of the existing hurricane protection projects. In future studies, apparent sea level change must be considered in the planning, design, and construction of any hurricane protective structure.

The near miss of Hurricane George in September 1998 heightened local concerns about the level of hurricane protection in the study area. State and local emergency operations managers have stated that evacuation of all of the approximately 1.4 million people in the project area is not possible in the short amount of time prior to landfall of a major hurricane. It is likely that 250,000 to 300,000 people would be unable to evacuate prior to the storm. Because much of the urban area is below sea level, those individuals not evacuating are at great risk since the American Red Cross and other agencies do not operate shelters in any parishes south of Lake Pontchartrain. This is due to the fact that there are, at present, no structures in the metropolitan

area that are certified as a shelter that could withstand a storm surge generated by a category 4 or 5 hurricane. Therefore, emergency planners believe that great loss of life would occur should a major storm strike the area.

In addition, overtopping of the existing protection areas would flood vast areas of the metropolitan area. Analysis of this possibility has shown that draining the flooded areas would take many months. With large areas of the metropolitan area flooded for long periods of time, extremely high damages to infrastructure, businesses, and homes can be expected. In addition, severe impacts to the Port of New Orleans, New Orleans International Airport, the major facilities owned by the U. S. Navy, and the NASA facility at Michoud can be expected.

Structural and agricultural damages were estimated for the existing and future (2050) without-project conditions. Sea level change and subsidence were incorporated into the estimation of future condition damages. Future without-project damages were estimated for each of these subprovinces based on the stages associated with the 100-year storm event provided by New Orleans District Hydrology and Hydraulics (H&H) Branch. It was assumed that the 100-year stage would not overtop the Lake Pontchartrain Hurricane Protection levees, the hurricane levees protecting Morgan City, and the authorized levees currently being constructed south of Houma as part of the Morganza to the Gulf, Louisiana project, under existing and future conditions (2050). These hurricane protection levees are built to an elevation that is equal to, or greater than, the stage associated with the existing condition 100-year storm event, and periodic levee lifts have been incorporated into their construction schedules. However, it was assumed that the hurricane protection levees protecting the Larose to Golden Meadow and the New Orleans to Venice study areas are subject to overtopping by the future condition 100-year stage. Sea level rise and subsidence has accelerated since the time these levees were authorized and constructed in the 1960s and 1970s.

Stage-damage data developed as part of the Flood Damage Estimation System (FDES) in 1980 for the Mississippi River and Tributaries (MR&T) project were used to estimate the flood damages that are expected to occur in Subprovinces 1, 2, and 3. The structural damage categories included: residential, commercial, industrial, public, and farm buildings. The damage values for the structural damage categories were adjusted to current price levels by using the Marshall and Swift building cost indices for southern Louisiana. However, it should be noted that damages would reflect the development that existed in 1980 and no adjustments were made to reflect any growth that has occurred since then. Based on data provided by the USACE MVN Geotechnical Branch, it was assumed that both the developed and agricultural land in the area would subside approximately 0.6 feet between 1980 and 2050. This predicted subsidence, which does not include the on-going subsidence of marshland, was used with the future 100-year stage to calculate the future condition structural and agricultural damages.

For the agricultural damages, the cleared acreage flooded was provided by stage. These acres were multiplied by the damage rate per acre in order to determine the future without project agricultural damages. The damage rates per acre were developed by the Louisiana State University Agricultural Center for each Louisiana parish based on the actual agricultural damages that occurred as a result of Tropical Storm Isidore and Hurricane Lili in 2002. Each of these storm events generated storm surges and heavy rainfall that affected the coastal Louisiana

area. The average agricultural damage rate per acre for Subprovince 1 totaled \$166, for Subprovince 2 totaled \$192, and for Subprovince 3 totaled \$361. The structural and agricultural damages were added to get the total existing and future without project flood control damages for each of the subprovinces.

The data were not available for the Louisiana parishes west of the city of Lafayette to the Texas border in Subprovince 4. Thus, 2000 census data were used to estimate the number and value of structures, while USGS quad maps containing 5-foot contour intervals and benchmarks were used to assign average ground elevations to the structures. The first floor elevations of these structures were assigned based on previous field experience in the study area. Structures are generally built to an elevation that is within one foot of the stage of the existing condition 100-year storm event. Since most of the structures near the Gulf of Mexico are built on piers several feet above the ground, they were assumed to have a total elevation of 9 to 10 feet. The structures further inland from the Gulf of Mexico were assumed to be built approximately 1 to 2 feet off the ground with a total elevation of 6 to 7 feet.

The future without-project condition stages were then compared to the height of the structures to calculate a depth of flooding for each structure. As discussed previously, the elevation of the houses was lowered by the subsidence of the land, 0.6 feet by 2050 to calculate future condition damages. Once the depth of flooding was determined, the depth-damage relationships developed for the Lake Pontchartrain and Vicinity Hurricane Protection Project were used to calculate the percentage of the structures and their contents damaged by flooding. These are the same curves that had been used to calculate damages for a previous hurricane protection feasibility study within the Louisiana coastal area. The damages were calculated and totaled for all structures to get the total existing and future condition without project structural damages.

The average depreciated value assigned to residential buildings in Subprovince 4 was determined to be \$48,000 in Cameron Parish and \$54,000 in Vermilion Parish. This value was assigned based on the average 2000 Census value for residential structures in each of these parishes, and then reduced by 20 percent for the value of the land and the depreciation of the structures. The average depreciated value, \$214,000, assigned to nonresidential structures in Subprovince 4 was based on the average value of nonresidential structures calculated for the Houma area in the Morganza to the Gulf, Louisiana Feasibility Study. A contents-to-structure value ratio (CSVR) of 0.57 was applied to the residential structures and 1.13 for nonresidential structures in order to determine the total value of the contents for residential and nonresidential structures. The CSVRs used for Subprovince 4 were taken from those developed for the Lake Pontchartrain and Vicinity Hurricane Protection Project and are consistent with those used to develop the stage-damage data and were used for a previous hurricane protection feasibility study within the Louisiana coastal area.

The agricultural acres were estimated using quad sheets and the 100-year surge levels provided by H&H Branch. These acres were then multiplied by the damage rate per acre to determine the existing and future without project agricultural damages. The average agricultural damage rate per acre for Subprovince 4 totaled \$159. The structural and agricultural damages were added to get the total existing and future without project flood control damages for Subprovince 4.

The structural and agricultural damages for the future (2050) without-project condition are shown by subprovince in **table 4-6**. Also displayed in the table are the number of structures, the total value of these structures, and the number of acres that are susceptible to flooding by the future condition 100-year stage.

Table 4-6 Future Without-Project Condition 2002 Price Level						
Sub-province	Number of Structures	Total Value (\$1,000s)	Structural Damages (\$1,000s)	Acres of Cropland	Agricultural Damages (\$1,000s)	Total Damages (\$1,000s)
1	12,329	\$ 5,593,026	\$ 727,213	67,054	\$ 16,570	\$ 743,783
2	18,256	4,254,614	871,444	90,056	16,947	888,391
3	17,418	3,296,641	574,165	208,368	70,680	644,845
4	12,992	1,345,351	512,249	142,000	22,578	534,827
Total	60,995	\$ 14,489,632	\$ 2,685,071	507,478	\$ 126,774	\$ 2,811,845

4.22.10.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): There would be short-term minor direct impacts, primarily associated with construction activities.

RO2 (geomorphic structure): There would be no direct impacts on hurricane levees as this restoration opportunity does not include any feature such as diversions that would directly impact a levee.

TSP: Direct impacts would be similar to RO1.

4.22.10.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): RO1 would incorporate diversions and marsh creation that would help preserve and rebuild marsh buffer zones that, in turn, would protect hurricane protection levees.

RO2 (geomorphic structure): Marsh creation, barrier system, and barrier shoreline restoration would provide some protection from storm surge.

TSP: Indirect impacts would be a combination of RO1 and RO2.

4.22.10.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): RO1 would incorporate diversions and marsh creation that would help to preserve and rebuild the marsh buffer zone that would, in turn protect hurricane protection levees.

RO2 (geomorphic structure): There would be cumulative storm surge protection provided by marsh creation, barrier system, and barrier shoreline restoration.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.11 Agriculture

4.22.11.1 Future Without-Project Conditions - The No Action Alternative

The impact to agriculture if no action is taken would be negative and result in an increase of saltwater intrusion, erosion of coast, and increase damages from storms. The loss to agriculture opportunities could cause a decrease in total acreage and yields of crops in the study area. Salinity levels in water used for crop irrigation are expected increase and with continued land loss, the risk of storm damage to agricultural resources would also increase. As the coastal landscape erodes and tidal surges force higher salinity waters further inland, many areas would have to counteract this effect by relocating water intakes to more northerly locations or by installing salt water barriers to protect their existing intakes. These expenses would undoubtedly be passed on to consumers. Agricultural damages, including losses to crops such as sugar cane, rice, soybeans, pastureland, etc. associated with future without-project conditions were estimated along the Louisiana coast. This study indicated that continued loss of barrier islands and wetlands would increase the risk of storm damage to agricultural resources. The loss of agricultural productivity associated with reduced amounts of freshwater available for crop irrigation and increased risk of storm damages would result in adverse economic impact to Louisiana and the Nation.

4.22.11.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): RO1 would cause minor losses of agricultural lands due to the footprint of diversions channels.

RO2 (geomorphic structure): There would be no adverse direct impacts.

TSP: Direct impacts would be similar to RO1.

4.22.11.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): RO1 would benefit agriculture by limiting saltwater intrusion into bayous and canals.

RO2 (geomorphic structure): There would be no adverse indirect impacts on agriculture. There would be some storm surge protection provided by marsh creation, barrier system, and barrier shoreline restoration.

TSP: Indirect impacts would be similar to RO1 and RO2.

4.22.11.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): There would be a potential for minor reduction to storm damages from hurricanes.

RO2 (geomorphic structures): Cumulative indirect impacts would be similar, but less than RO1, due to fewer restoration features.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.12 Forestry

4.22.12.1 Future Without-Project Conditions - The No Action Alternative

There would be a loss of forestry opportunities in the future without project. By taking no action the coast of Louisiana would continue to erode, which would lower the potential acreage of forestland. Lower acreage would decrease productivity and decrease yields of timber. There is also a potential for increased damages from storms and saltwater intrusion to forestry. Overall, taking no action could produce negative impacts to forestry. As a result to taking no action, the economic implications could be negative. If there is a decrease in acreage and yields of timber, jobs in the forestry industry could decrease, which could increase the unemployment rates in the study area. Also, income for forestry landowners would decline if no action were taken. The loss of forestry productivity would result in adverse economic impact to Louisiana and the Nation.

4.22.12.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): There would be no significant direct impacts, except to the degree that forest acres may be used for project construction, which is not anticipated at this time.

RO2 (geomorphic structures): There would be no direct impacts.

TSP: Direct impacts would be similar to RO1.

4.22.12.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): There may be an increase in productivity of timber due to inputs of freshwater, nutrients, and sediments. If timber production increases, then there could be a potential to increase forestry-related jobs, employment, and income.

RO2 (geomorphic structures): Indirect impacts are unlikely.

TSP: Indirect impacts would be similar to RO1.

4.22.12.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): There is the possibility to reduce storm-related damages and increase opportunities for forestry-related activities. There could be positive economic opportunities for forestry-related jobs, employment, and income. These positive cumulative impacts would be in contrast to negative cumulative impacts associated with the continued harvesting of wetland forests areas, such as the present timber harvesting operation occurring near Maurepas swamp.

RO2 (geomorphic structure): Cumulative impacts to forestry are unlikely.

TSP: Cumulative impacts would be similar to RO1. These positive impacts would be in contrast to the continued timber harvesting of wetland forests areas, such as the present forest harvest operations occurring near Maurepas swamp.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.22.13 Water Supply

4.22.13.1 Future Without-Project Conditions - The No Action Alternative

In many coastal areas of southeastern Louisiana, fresh surface-water supplies would be limited to the Mississippi River, Atchafalaya River, and many of their distributaries. Because many of these water bodies are controlled by levees and flows are maintained, it is doubtful that they would be affected by loss of surrounding wetlands. Also, because these water bodies are the major sources of freshwater in southeastern Louisiana, water use would be largely unaffected.

However, Bayou Lafourche currently experiences periodic saltwater intrusion, primarily from Company Canal and the GIWW. Salinities in this bayou could increase, limiting freshwater supplies, if the surrounding area became saltier. The economic effects would be felt by industry, agriculture, and the public supply in this area. Because fresh ground water is very limited or unavailable in most of the LCA study area, the larger water users in this area, primarily industry and public supply, would have to treat (desalinate) the water for salinity or find new sources of fresh water. This could affect public water supply, agricultural use, and industrial use in this area, resulting in increased costs for water treatment (desalination). Businesses could be forced to relocate, thereby potentially adversely affecting jobs, income, population, and property values.

In southwestern Louisiana, fresh surface and ground water are available in most coastal areas. However, surface water in some areas, such as the Calcasieu Basin, experience periodic saltwater inundation. Much of the water use in these areas is agricultural and farmers use ground water when surface supplies become salty. If surface-water salinities increased in coastal areas because of wetland loss and erosion, it is likely that surface-water withdrawals would decrease and withdrawals from ground water would increase. Fresh ground water is available in sufficient supplies in most areas of southwestern Louisiana to offset any losses of surface supplies. However, a saltwater-freshwater interface is present in the aquifer system, extending inland from the coast along the base of the aquifer system as a wedge. In coastal areas, freshwater overlies saltwater. Increased withdrawals in coastal areas could cause the interface to move further inland or cause saltwater to up-cone from the base of the aquifer towards pumping wells. This could affect agricultural use in that area resulting in increased costs for water treatment. Potentially this agricultural activity could decline, thus adversely affecting the local economy through declines in jobs, income, population, and property values.

4.22.13.2 Restoration Opportunities - Direct Impacts

RO1 (deltaic processes): Direct impacts would be minimal, provided that measures are taken during construction to minimize impacts to any existing water supplies in the area, and that the design of restoration features account for any disruptions of water supply during the construction period.

RO2 (geomorphic structures): Would cause little, if any, direct impacts on the water supply.

TSP: Direct impacts would be similar to RO1.

4.22.13.3 Restoration Opportunities - Indirect Impacts

RO1 (deltaic processes): Indirect impacts would primarily result in a decrease in saltwater intrusion. Diversions of Mississippi River water may negatively impact freshwater supplies to downstream users of Mississippi River water. Increased flows into the receiving areas of Subprovinces 1 and 2, may enhance freshwater supply to users in those areas. Increased flows into Bayou Lafourche and the Terrebonne marshes would enhance freshwater supplies to users in those areas. Reduced saltwater intrusion into areas, such as Houma, may prolong freshwater supply to users in those areas.

RO2 (geomorphic structures): Indirect impacts of RO2 could primarily be a decrease in saltwater intrusion in the MRGO area.

TSP: Indirect impacts would be a combination of RO1 and RO2.

4.22.13.4 Restoration Opportunities - Cumulative Impacts

Table 4-1 summarizes the cumulative impacts for RO1, RO2, and the TSP.

RO1 (deltaic processes): Cumulative impacts to water supply would primarily be related to the incremental impact of all past, present and future actions effecting water supply such as existing freshwater diversions (e.g., Caernarvon, Davis Pond, West Bay, etc.); those diversions currently in planning or construction (e.g., Maurepas, etc); and similar actions. Hence, for RO1, potential cumulative impacts would be the incremental decrease of freshwater supply in areas with water intakes along the Mississippi River (e.g., Point a la Hache, Port Sulfur, Venice, etc.). However, any potential adverse impacts to community and industrial water supplies would be mitigated. In Subprovince 3, it is anticipated that the proposed features would increase freshwater supply to areas such as Houma. Salinity in lower Bayou Lafourche would be reduced.

RO2 (geomorphic structures): Cumulative impacts would primarily be a decrease in saltwater intrusion in the MRGO area.

TSP: Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of RO1 and RO2.

These general direct, indirect, and cumulative impacts would be further developed on a project-by-project basis.

4.23 OTHER CUMULATIVE IMPACTS

The primary purpose of this chapter is to present the direct, indirect, and cumulative impacts of the conceptual LCA restoration opportunities on significant resources. However, 40 CFR 1508.7 defines cumulative impacts as:

"...the impact on the environment which results from the incremental impact of the action when added to *other* past, present, and future actions *regardless of what agency (Federal or non-federal) or person undertakes such other actions.*"

The emphasis has been added. The April 2002 USEPA-hosted workshop on "The NEPA: Conducting Quality Cumulative Effects Analysis," indicated that considering the past, present, and reasonably foreseeable future provides a needed context for assessing cumulative impacts. The inclusion of other actions occurring in the proximity to the proposed action is a necessary part of evaluating cumulative effects. Agencies should identify activities occurring outside their jurisdiction that are affecting the same resources being affected by their actions. Hence, this section summarizes other cumulative impacts to the Louisiana coastal by other Federal, State,

Local, and private coastal restoration efforts and the District's water resources development projects.

4.23.1 Federal, State, Local And Private Restoration Efforts

4.23.1.1 General

This section describes other Federal, state, local, and private restoration efforts in the Louisiana coastal area. The CWPPRA acreage for wetland creation projects was collected from "Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1998. Coast 2050: Toward a Sustainable Coastal Louisiana. Louisiana Department of Natural Resources. Baton Rouge, LA. 161p." Information on the Water Resources Development Act wetland creation projects was compiled from the "Water Resources Development in Louisiana 1998" by Saucier (1998). Other information was derived from web sites including www.lacoast.gov for CWPPRA input, www.coast2050.gov for LCA input, and www.savewetlands.org for LDNR input. The Regulatory Branch of the District provided information for each parish on the acres of jurisdictional waters (and wetlands) of the United States requested to be permitted, the acres actually permitted, and the number of acres mitigated. Wetland acreage created or planned to be created by the beneficial use of dredged material was gathered from the Beneficial Use Monitoring Program (BUMP; UNO 2001) which examined the beneficial use of dredged material disposal history along selected navigational channels in Louisiana and the cumulative landscape history for the beneficial use monitoring program sites: 1985-2000. Other data acreages were collected from phone conversations with agencies of the LDNR, NRCS, and the Soil and Water Conservation Committee (SWCC) for the coastal parishes of Louisiana.

CWPPRA ("Breaux Act") Restoration Projects: Over the past 12 years CWPPRA, with the completion of the 12th Priority Project List in 2003, has authorized a total of 141 projects. When constructed, all of the projects authorized to date, would create, restore, protect, or enhance approximately 130,000 acres at a cost of approximately \$1.3 billion dollars. Despite the acres gained by implementation of the CWPPRA-funded projects, these acres and those preserved by the existing freshwater diversions (reintroductions) from the Mississippi River would prevent only about 25-30 percent of the predicted future marsh loss in Louisiana. Hence, there is a need for a coast wide, ecosystem-level restoration effort that would require significantly greater funding than was conceptualized and is authorized for CWPPRA because the state would suffer a net loss of approximately 513 square miles of coastal wetlands by 2050.

Water Resources Development Act (WRDA) Restoration Projects: The Water Resource Development Acts (WRDA), the first of which was passed in 1976, authorizes the Secretary of the U.S. Army and the District to study and/or implement various projects and programs for improvements to rivers and harbors of the United States and for other purposes. A number of Water Resources Development Acts contain general environmental provisions pertinent to the Civil Works water resources development program or to the management of environmental resources. A number of sections from these Acts pertain to specific projects or studies for environmental purposes. For example, Caernarvon and Davis Pond are two WRDA-authorized, large scale, freshwater diversion projects which divert freshwater (and to a lesser extent sediment

and nutrients) to counteract saltwater intrusion, to help offset marsh subsidence, and to enhance fish and wildlife. These projects would benefit over 40,000 existing acres of wetland habitat.

Section 1135 (PL 99-662) of WRDA 1986 authorizes the District to review the operation of its existing water resources projects to determine the need for modifications in structures and operations for the purpose of improving the quality of the environment in the public interest. A \$25 million annual limit was authorized for this section with 25 percent of the cost of any modification to be paid by a non-Federal sponsor.

Section 204 (PL 102-580) of the WRDA 1992 authorized the Secretary of the Army to carry out projects for the protection, restoration, and creation, of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance of an authorized Federal navigation project. Any project undertaken pursuant to this section shall be initiated only after non-Federal interests have entered into a cooperative agreement in accordance with the requirements of Section 221 of the Flood Control Act of 1970 in which the non-Federal interests agree to provide 25 percent of the cost associated with construction of the project. The non-Federal interests must also agree to pay 100 percent of the operation, maintenance, replacement, and rehabilitation costs associated with the project.

Together, Section 1135 and Section 204 projects have created about 6,245 acres in Louisiana.

Louisiana State Restoration Projects: The State of Louisiana is partnered with private companies and agencies within the state and Federal Government to create, restore, and protect wetlands and shoreline from degradation. The types of projects include hydrologic restoration, beneficial use of dredged material, marsh management, marsh creation, shoreline protection, freshwater diversion, vegetation planting, sediment and nutrient trapping, sediment diversion, and barrier island restoration. These projects are scattered within the four subprovinces of the coastal zone of Louisiana. As of 2003, the total acreage created, restored, or protected for Subprovince 1 is 2,443 acres, Subprovince 2 is 9,143 acres, Subprovince 3 is 4,865 acres, and Subprovince 4 is 4,574 acres; for a total of 21,025 acres.

Vegetation Restoration Projects: The LDNR, NRCS, and Soil and Water Conservation Committee (SWCC) are the agencies involved with vegetative plantings in coastal Louisiana. Within the four subprovinces, there were 193 vegetation projects as of 2003. The total acreage benefited for each subprovince is as follows: Subprovince 1 had 486 acres, Subprovince 2 had 1,004 acres, subprovince 3 had 1,785 acres, and Subprovince 4 had 1,973 acres created, restored, and/or protected. The types of vegetation planted include smooth cordgrass (*Spartina alterniflora*), giant cordgrass (*Zizaniopsis milacea*), seashore paspalum (*Paspalum vaginatum*), California bulrush (*Schoenoplectus californicus*), roseau cane (*Phragmites australis*), bitter panicum (*Panicum amarum*), marsh hay cordgrass (*Spartina patens*), salt grass (*Distichlis spicata*), bald cypress (*Taxodium distichum*), common bermuda (*Cynodon dactylon*), panic grass (*Panicum sp.*), gulf cordgrass (*Spartina spartinae*), and black mangrove (*Avicennia germinans*). These plantings have rehabilitated fresh, brackish, intermediate, and saline marsh, swamp, and barrier islands.

Louisiana Parish Coastal Wetland Restoration Program (PCWRP): The Parish Coastal Wetlands Restoration Program (PCWRP), also known as the "Christmas Tree Program," is designed to encourage public involvement and participation in coastal restoration. Wooden enclosures are filled with recycled Christmas trees that have been donated by the public. These structures are built in close proximity to the shoreline and absorb wave energy, protecting existing marsh or vegetation. Sediment accumulates behind these structures and promotes subsequent colonization and growth of new marsh vegetation. Christmas tree fences are relatively inexpensive, with an average cost of \$50 per linear foot.

Federal Emergency Management Agency (FEMA): The Federal Emergency Management Agency (FEMA) provides aid to people and areas that have been adversely affected by presidentially declared natural disasters. Aid provided by FEMA includes vegetative plantings, beneficial use of dredged material, sand fences on barrier islands, repairing water control structures, and bank repair. As of 2003, FEMA assisted the state of Louisiana after several hurricanes, tropical storms, and flooding events with 8 projects, which benefited over 5,379 acres.

Mitigation in the Coastal Zone: From 1 January 1998 to 23 October 2003, the Regulatory Branch of the District received requests for permitting (including standard, general, and nationwide permits) a total of about 15,202 acres of jurisdictional waters (and wetlands) of the United States located within the 17 parishes comprising the Louisiana Coastal Plain (**table 4-7**). **Table 4-7** also shows that a total of about 12,355 acres were actually permitted, with about 15,228 acres of compensatory mitigation. Acreages of wetlands impacted under permits for Section 404 of the Clean Water Act include direct and indirect affected wetlands; and include not only coastal marsh impacts, but also all impacts to waters of the United States.

Mitigation of federal civil works projects (e.g., flood and hurricane protection projects) in the Louisiana Comprehensive Study area includes approximately 5,537 acres. Mitigation of civil works flood and hurricane protection projects include the following:

- Larose to Golden Meadow project mitigation was the hydrologic restoration of Point au Chein WMA preserving about 4,600 acres.
- New Orleans to Venice, Louisiana project mitigation to compensate for project-associated wetland losses on Reach B has been constructed. This consists of five crevasses in the Mississippi River Delta to promote marsh creation (one constructed in 1986 and the remaining four constructed in 1995). These five crevasses created approximately 225 acres of fresh marsh. Remaining mitigation for Reaches A, C, and WBRL, consisting of creating and preserving marsh in the Pass a Loutre State Waterfowl Management Area, was completed in 1997. This remaining mitigation created approximately 105 acres of marsh and nourished and preserved approximately 1,230 acres of wetlands.
- Lake Pontchartrain project mitigation involved construction of a breakwater to prevent breakthrough of Lake Pontchartrain into the Manchac WMA. It preserved about 3,400 acres.
- West Bank and Vicinity, New Orleans, Louisiana project mitigation to compensate for marsh losses has been constructed. This consists of a tire/timber pile breakwater to stop

a projected 370 acres of wave-induced coastal erosion at the Netherlands area on the west side of Lake Salvador at the Salvador Wildlife Management Area (WMA). The breakwater was completed in 1991. The remaining mitigation to compensate for wooded land losses has not been constructed, due to design changes and expansion of the project. This mitigation will consist of the acquisition, preservation, and habitat development of wooded wetlands; and is currently being documented in a Mitigation Report.

Table 4-7 Standard, General and Nationwide Permits Acres Requested to be Permitted, Acres Actually Permitted, and Acres Mitigated in the Louisiana Coastal Zone. (source: The District's Regulatory Branch database)				
Parish	Entirely (E) or Partially (P) Within Coastal Zone	Acres Requested	Acres Permitted	Acres Mitigated
Calcasieu	P	2,118	1,846	2,087
Cameron	E	883	862	896
Iberia	P	264	252	227
Jefferson	E	828	715	641
Lafourche	P	1,283	1,064	1,829
Livingston	P	816	696	960
Plaquemines	E	1,262	1,055	2,084
St. Bernard	E	269	219	237
St. Charles	E	822	533	481
St. James	E	231	223	248
St. John the Baptist	E	410	315	494
St. Martin	P	451	429	512
St. Mary	P	613	535	576
St. Tammany	P	2,754	1,966	2,248
Tangipahoa	P	451	353	388
Terrebonne	P	1,310	919	918
Vermilion	P	437	373	402
TOTAL		15,202	12,355	15,228

- Louisiana State Penitentiary project mitigation was reforestation of about 166 acres on Angola lands. (Note: this project is not in the coastal zone.)
- Mississippi River Levees project mitigation was the reforestation of about 30 acres of land in the Bonnet Carre Spillway.

Non-Governmental Organizations (NGOs): Public and private parties - non-governmental organizations (NGOs) - privately manage wetlands and other coastal habitats to enhance, preserve and/or restore coastal wetlands throughout the LCA study area. NGOs include: private

individual landowners, family estates, and corporations; non-profit organizations; and academic institutions. NGOs manage coastal wetlands for many different reasons, including: to enhance, preserve or restore wetland habitat functions and values; to attract waterfowl and game fish for their ecological importance and/or aesthetics; to prevent property damage and/or land loss; for agriculture and aquaculture; and for various other reasons. Typical land and water management practices that NGOs apply throughout coastal Louisiana include: shoreline stabilization; plugging oilfield canals to prevent saltwater intrusion; gapping spoil banks to increase fresh water exchange; rebuilding spoil banks to prevent erosion and saltwater intrusion; and earthen terracing to create wetland habitat and reduce erosion. In addition, water level management practices are commonly used to enhance water quality and habitat for fish, waterfowl, and wildlife. Aside from recognition of a few individual conservation organizations restoration efforts, a comprehensive accounting of the various NGO restoration activities in coastal Louisiana is lacking. However, the positive cumulative benefits of NGO coastal restoration efforts are valuable to overall coastal Louisiana restoration efforts.

Examples of public and private parties involved in wetlands preservation or restoration activities in coastal Louisiana include: Coastal America, Corporate Wetlands Restoration Partnership, Gulf Coast Joint Venture, Audubon Society, National Fish and Wildlife Foundation, Nature Conservancy, National Wildlife Federation, the North American Wetlands Conservation Act (NAWCA), administered by the USFWS; and the Wisner Foundation, in a community-based partnership with the University of New Orleans, Morris P. Hebert, Incorporated, the Barataria-Terrebonne Estuary Program, Restore America's Estuaries Program, Chevron and the Federal government. A more detailed accounting of these restoration activities is presented in section 4.23.1 Federal, State, Local and Private Restoration Efforts.

Specific examples of coastal restoration activities performed by public and private NGOs include:

The Nature Conservancy of Louisiana, a non-profit organization, uses private donations to purchase large tracts of land for the purpose of preserving important and rare natural areas.

Ducks Unlimited, Incorporated, through private contributions, has constructed earthen terraces in 3,226 acres of open water in the Cameron Creole Watershed on both private and public lands, and is committed to constructing other similar terracing projects in the near future, including a project during the summer of 2004 in Cameron and Vermilion Parish, a project near Boggy Bayou in Cameron Parish, and a project on the Point Aux Chene Wildlife Management Area (Source, phone conversation with Chad J. Courville, Regional Biologist, Ducks Unlimited, Incorporated, 27 May, 2004).

The Wisner Foundation, in a community based partnership with the University of New Orleans, Morris P. Hebert, Incorporated, the Barataria-Terrebonne Estuary Program, Restore America's Estuaries Program, Chevron and two Federal Government Organizations, have implemented a 2,000-acre project within the 35,000-acre Wisner Foundation land, which includes 45 acres of brackish marsh, shoreline and spoil bank protection, plantings and sediment diversions (The Lafayette Daily Advertiser, May 16, 2003).

One of the more significant contributions to the restoration and enhancement of coastal wetlands has been a result of the North American Wetlands Conservation Act (NAWCA), administered by the USFWS. The 1999 and 2001 biennial NAWCA report presented to Congress cites 30,558 acres of restoration and 340,348 acres of enhancement in coastal Louisiana wetlands.

4.23.1.2 Impacts Of Restoration Opportunities On Other Coastal Restoration Efforts

From a programmatic and conceptual perspective, the potential cumulative impacts of each restoration opportunity on other Federal, state, and local restoration efforts would generally be similar and would be the sum total restored acres (and the associated functions and values) of these other restoration efforts plus the total acres (and associated functions and values) protected, created and/or restored by each plan in the final array of coastwide plans compared to the continued and accelerated loss of wetlands throughout the United States.

The cumulative impacts of the near-term plans on other Federal, state, and local restoration efforts would generally be the net restored acres (and the associated functions and values) of each feature in each near-term plan plus the net acres (and associated functions and values) protected, created and/or restored by these other Federal, state, local and private restoration efforts, compared to the continued and accelerated loss of wetlands throughout the United States. **Table 4-8** displays the net acres in 50 years created, restored, and/or protected by other Federal, state, local, and private restoration efforts.

Table 4-8
Net Acres in 50 years Created, Restored, and/or Protected by
Other Federal, State, Local, and Private Restoration Efforts

	Subprovince 1 (acres)	Subprovince 2 (acres)	Subprovince 3 (acres)	Subprovince 4 (acres)	Totals (acres)
Breaux Act CWPPRA	33,690	44,913	25,057	30,486	134,146
State	2,543	9,043	5,200	1,972	18,758
PCWRP	14	41	371	31	457
*Mitigation Civil Works Projects	4,990	0	5,000	0	9,990
*Mitigation Regulatory Permits	6,411	3,199	2,635	2,983	15,228
Vegetation	535	878	1,785	1,931	5,129
Section 204/1135, Beneficial Use	226	414	1,293	3,525	5,458
WRDA	16,000	33,000	0	0	49,000
**Other	0	2,000	50,000	3,226	426,132
TOTALS	64,410	93,490	91,344	44,158	664,298

Source: The state, parish, FEMA, vegetation, WRDA, Sections 1135/204, and /beneficial use are from the state book: "Coastal Restoration Division Annual Project Reviews, Dec 2002". CWPPRA (Breaux Act) acres are from the District's November 2003 Task Force book and have been furnished by USFWS. Permit mitigation is from the District's Regulatory Branch database. Civil works mitigation is from the District's files. Other is 50,000 of non-mitigation land bought in fee in the Atchafalaya Basin by the District.

*In the best-case scenario, compensatory mitigation (for civil works projects and regulatory permits) results in no net loss of wetlands. Hence, it is not the intent to imply that compensatory mitigation acreages would contribute to a net increase in wetlands as a result of the Clean Water Act Section 404 program. Rather, these figures represent an accounting of the various cumulative impacts to coastal wetlands from Federal, state, local, and private restoration efforts.

**Includes 30,558 acres restored and 340,348 acres enhanced by North American Wetlands Conservation Act (NAWCA), administered by the USFWS; unable to determine exact locations.

4.23.2 Other Cumulative Impacts: Natural And Human Activities Affecting Coastal Land Loss

4.23.2.1 General

The following description of cumulative impacts of coastal land loss factors in the Mississippi River deltaic plain and chenier plain is based, respectively, on Penland et al. (2000) and the October 2002 report prepared for the Louisiana Coastal Wetlands Conservation and Restoration Task Force entitled "Hydrologic Investigation of the Louisiana Chenier Plain" (HILCP). (HILCP 2002). Although these studies represent the most recent comprehensive treatment of the subject, there is some disagreement regarding the findings of both of these studies, especially since neither of these studies was peer reviewed. The Penland et al., study was sponsored by the Argonne National Laboratory, Gas Research Institute, the District, and the USGS, with authors from the University of New Orleans, Louisiana State University, the District, USGS and the Plaquemines Parish Government. The HILCP study was prepared by the LDNR with contributing authors from the University of Louisiana at Lafayette, USGS, USFWS, and the CWPPRA study which includes the USFWS, National Marine Fisheries Service (now NMFS), NRCS, USEPA, and the District.

4.23.2.2 Delta Plain- Cumulative Impacts Of Coastal Land Loss Processes

Penland et al., (2000) provide the only known comprehensive coastal land loss process classification scheme for the Mississippi River deltaic plain. Although there is some disagreement regarding the findings of this study, Penland et al., emphasize that their analysis describes local processes which occurred over a 60 year period and may not fully reflect the contribution of important regional processes such as river control, subsidence, and eustacy (change in global sea level) which were active even prior to the acceleration of land loss rates in the late 1960s. Although these regional processes play an important role in shaping coastal Louisiana, no studies have specifically quantified the contribution related to each.

Table 4-9 (adapted from Penland et al., 2000) displays the acres of coastal land lost in the Deltaic Plain between 1932 and 1990 due to three primary land loss processes: erosion, submergence, and direct removal. Penland et al., (2000) identify two major causes of these processes: natural and cultural (human-induced). Natural actions include phenomenon such as wind-generated wave erosion along the outer gulf shoreline and within inland waters, channel flow erosion due to the currents generated during the ebb and flow of the tides, natural water logging and faulting. Cultural actions include human activities such as navigation, channel dredging, building of impoundments, resource extraction, and excavation of ponds.

Table 4-9 Cumulative Coastal Land Loss in the Delta Plain Between 1932 and 1990. (Source: Penland et al., 2000)	
Process of Coastal Land Loss	Acres
EROSION	
Natural Wave	181,090
Navigation Wave	21,821
Channel Flow	10,369
Subtotal	213,280
SUBMERGENCE	
Altered Hydrology- Oil and Gas	172,174
Altered Hydrology- Multiple	148,666
Natural Waterlogging	21,069
Failed Land Reclamation	16,403
Altered Hydrology- Impoundments	7,992
Altered Hydrology- Roads	4,825
Faulting	3,921
Herbivory	561
Subtotal	375,612
DIRECT REMOVAL	
Oil/Gas Channel	76,978
Navigation Channel	11,293
Borrow Pit	11,130
Access Channel	1,312
Burned Area	729
Sewage Pond	308
Agricultural Pond	179
Drainage Channel	109
Subtotal	102,039
TOTAL	690,931

4.23.2.3 Chenier Plain- Cumulative Impacts Of Coastal Land Loss

The HILCP (2002) describes impacts in the Mermentau and Calcasieu-Sabine Basins in the Chenier Plain. The findings of this study (summarized below) are based upon an analysis of

long- and short-term hydrographic records, recent marsh elevation data, landscape change analysis, and hydrologic modeling.

Mermentau Basin

Historical causes of landscape change in this basin include causes of loss other than prolonged marsh flooding. Human activities related to drainage improvements, navigation projects, saltwater intrusion mitigation, water control structures, agriculture irrigation improvements, highway construction, access canals for the oil and gas industry, flood control, and wetland and wildlife management practices have altered the hydrology of the Mermentau Basin.

The lower Mermentau Basin comprises two subbasins, the Lakes subbasin (located south of the limit of the coastal zone and north of Louisiana Highway 82 and the Gulf of Mexico) and the Chenier subbasin (located between Louisiana Highway 82 and the Gulf of Mexico).

In the Lakes subbasin, construction of navigation channels, locks and water control structures has altered the historical north-south river and tidal-driven hydrology and shifted it to an east-west system that drains through the GIWW. The Mermentau Lakes subbasin now functions more as a freshwater reservoir and less as the low-salinity estuary it was prior to these alterations. Many natural resource managers believe that the District-operated locks and control structures have resulted in elevated water levels and prolonged marsh flooding that is slowly drowning the marsh in this subbasin. However, analysis of historical records shows that the rates of rise are irregular both over time and among the structures. Furthermore, rates of water level rise in the Mermentau Lakes subbasin do not exceed the reported ability of fresh and intermediate marshes to maintain elevation in response or relation to a rising sea.

Impacts

Drainage, Navigation, and Water Control Structures: Drainage improvements (clear, deepen, and straighten) of the upper Mermentau River and its four major tributaries, enlargement of the Mermentau River, and dredging of seven cutoffs have facilitated the movement of rainwater and agricultural discharge from the upper portion of the basin into the lower portion of the basin and resulted in more rapid drainage into the Lakes subbasin following rain events. Over time, wake erosion has progressively widened the major Federal navigation projects (GIWW, the Inland Waterway (old GIWW), and the Freshwater Bayou Canal) in this basin. This widening was accompanied by the breaching of dredged material disposal banks thereby allowing saltwater intrusion into previously fresh areas consequently compromising the freshwater reservoir relied upon by the regions rice farmers.

Five water control structures in the Mermentau Basin are operated to moderate water levels, to allow for limited floodwater drainage, and to prevent saltwater intrusion from navigation channels and the Gulf of Mexico. The HILCP (2002) states that the goals of maintaining water levels for navigation and controlling salinity are mutually exclusive under certain conditions. Water levels appear to be rising both inside and outside of all five water control structures. The rates of rise are within the range of vertical organic matter accretion, so that it seems likely that vertical accretion in this area would be sufficient to keep pace with the rate of relative sea level

rise in this region. Prolonged flooding (greater than 30 days), such as happens during operation of the Calcasieu Lock, and especially with the Schooner Bayou and Catfish Point control structures, can adversely affect wetland primary productivity and sustainability. Prolonged flooding may increase marsh edge erosion and could stress less flood-tolerant plant species. Habitat shifts in the Mermentau Basin from 1949 through 1997 show a long-term trend toward freshening of the Lakes subbasin, and increasing salinity in the Chenier subbasin. However, despite preliminary evidence that prolonged marsh flooding occurs in the vicinity of Catfish Point, there is no clear research findings linking high water levels in the Lakes subbasin to marsh loss or to increased shoreline erosion in the Mermentau Basin. The HILCP concludes that the general understanding of the relationship between marsh stability, marsh elevation, and surface flooding is, at best, inconclusive. The HILCP recommends that basic applied research in this area is needed.

Access for Estuarine Organisms: The historic oligohaline estuary of the Mermentau Basin has been converted to the current freshwater reservoir. The existing shrimp and crab fisheries viability depends upon the operation of the locks and water control structures. The HILCP reports that during years when high navigation traffic is reported through the structures fishermen report excellent harvests. When structures are closed, established organism access routes are closed and shrimp and crab landings fall. However, the District regularly operates the structures to allow organisms access to the basin.

Agricultural Runoff and Turbidity: Irrigation improvements such as the Bell City Drainage Canal and the Warren Canal were dredged to supply freshwater from the Lakes subbasin to rice farmers in the Upland subbasin. However, agricultural runoff from these canals contributes to turbidity problems in Grand and White Lakes. Agricultural runoff increases the turbidity in Grand and White Lakes thereby reducing the habitat quality for submerged aquatic vegetation and for the fishery species that depend on it. The Louisiana Cooperative Extension Service and the NRCS are currently working with Mermentau rice farmers to institute a series of best management practices to reduce sediment runoff into the system.

Oil and Gas Industry Access Canals: All of the oil and gas access canals have facilitated saltwater intrusion into brackish and intermediate marshes and have been cited as a major cause of land loss.

Highway Construction: Louisiana Highway 82 and 27 disrupt historical drainage patterns. A drainage system of 32 culverts and 12 bridges on Highway 82 were constructed to address landowner concerns about obstruction of drainage. However, this system does not have the capacity to effectively drain the Lakes subbasin.

Storm Flooding: Some area residents feel that water levels in the Lakes subbasin are too high due to water control structures. Drainage improvements to the Upland subbasin may have decreased retention time in this subbasin and exacerbated flooding in the Lakes subbasin, while downstream water control efforts restrict the drainage potential and lead to frequent flooding.

Salinity: Salinity records from the Schooner Bayou and Catfish Point control structures for the period 1 January 1995 - 31 December 1998 shows that salinity outside of the structures rises in

April, increased to a September peak, then declines through December and into the following March. This pattern is mimicked inside of the structures, but the increases are somewhat muted.

Calcasieu-Sabine Basin

The Calcasieu-Sabine Basin was historically interconnected with the Mermentau Basin. However, hydrologic alterations (navigation corridors, e.g., Calcasieu Ship Channel and Sabine - Neches Ship Channel) have made these two basins more hydrologically distinct. In contrast, the Gum Cove Ridge historically was a hydrological barrier separating the Calcasieu and Sabine basins. Construction of the Gulf Intracoastal Waterway that connected the Calcasieu Ship Channel and the Sabine-Neches Ship Channel. This hydrologic coupling altered the hydrologic circulation by disrupting the historical north-south estuarine gradient and diverting to the east and west riverine inflows and saltwater intrusion induced via navigation channels.

Hydrology in this basin has been altered by three principle means: channeling saltwater into the historical low-salinity estuary; creating a more rapid channelized loss of riverine inflows when the tide ebbs; and increasing tidal amplitude.

Impacts

Navigation Channels, Saltwater Intrusion, and Salinity Control: The Calcasieu Ship Channel (CSC) has been maintained for navigation since 1874 and has been enlarged to a current width of 400 feet and current depth of 40 feet. Removal of the natural channel mouth bar, and subsequent widening and deepening of the CSC, allowed increased saltwater and tidal intrusion into the estuary. This resulted in marsh loss, tidal export of organic marsh substrate, and an overall shift to more saline habitats. Completion of the Calcasieu River Saltwater Barrier in 1968 minimizes the flow of the saltwater wedge into the upper reaches of the Calcasieu River to protect agricultural water supplies.

Habitat: Changes in the historical patterns of habitat in the Calcasieu-Sabine basin are all directly tied to human activities, primarily those associated with the exploration, development, and transportation of petrochemicals. Generally, there have been no basin-wide shifts towards more saline environments since 1949. However, there have been site-specific shifts toward more saline environments adjacent to the Calcasieu Ship Channel. In contrast, natural resource management activities have had a lesser effect, but include landscape changes and freshening in the present day Sabine National Wildlife Refuge impoundments and the Cameron-Creole Watershed Project.

The HILCP states that habitats have not remained stable. Marsh plant communities are determined, in large part, by the salinity regime to which they are exposed. Saltwater intrusion induced through navigation channels, petrochemical exploration, storms, and herbivory have cumulatively caused land loss and major plant community changes over the past 50 years. This is evidenced by the loss of saw grass as the dominant wetland plant community in the late 1950s and early 1960s.

Salinity: A negative correlation between Sabine River discharge and salinity across the Calcasieu-Sabine basin suggests that Sabine River discharges may be a factor in moderating salinities in Upper Calcasieu Lake.

Chicot Aquifer Depletion: Groundwater withdrawals associated with irrigation and industrial pumping have elevated the freshwater-saltwater interface in all three of the distinct sand units that characterize the aquifer. This has resulted in reversal of the natural southerly freshwater flow and a northward movement of saltwater in the aquifer. There is evidence of northern encroachment of the saltwater wedge in northern Cameron Parish.

Potential Threats to Freshwater Inflows: Interstate demands on water may play a large role in the future status of the Calcasieu-Sabine Basin. First, the proposed expansion of the Sabine-Neches Ship Channel to 50 foot depth and 500 foot width, from the Gulf of Mexico to the Port of Beaumont would be expected to exacerbate saltwater intrusion during the flood tide and freshwater outflow during the ebb tide resulting in higher salinities in the marsh. Second, the East Texas Water Plan (Texas Senate Bill 1) presently recommended strategies do not include recommendations to address projected water shortages by inter-basin transfers of Sabine River water near Houston. However, the inter-basin transfer of water from the Sabine Basin remains a long-term strategy that could, cumulatively, impact the Calcasieu-Sabine Basin.

4.25 SUMMARY OF IMPACTS OF THE TENTATIVELY SELECTED PLAN (TSP)

This PEIS compares the direct, indirect, and cumulative impacts for three restoration opportunities, including the TSP. These restoration opportunities are directed, to varying degrees, at conservation and restoration of deltaic processes, geomorphic structures, or combinations thereof. The TSP includes significant ecosystem restoration features in all four coastal Louisiana subprovinces that would address the critical needs in the near-term. In the Deltaic Plain, the TSP would reintroduce freshwater and sediment from the Mississippi and Atchafalaya Rivers in multiple locations and scales. It would also restore critical geomorphic structures in all subprovinces. Of the 3 near-term restoration opportunities, the TSP will best address the most immediate and critical needs of the ecosystem by promoting the distribution of riverine freshwater, nutrients, and sediments using natural processes and ensuring the structural integrity of the estuarine basins. Only the TSP, of the three restoration opportunities, meets all study objectives. It accomplishes hydrogeomorphic objective #1 (establish dynamic salinity gradients), #2 (increase sediment input), and #3 (sustain natural landscape features). It also achieves ecosystem objective #1 (sustain diverse habitats). TSP would have a minor effect in achieving ecosystem objective #2 (reducing gulf hypoxia). However, there is future opportunity to expand on achieving this particular objective. The TSP was formulated using the study guiding principles.

Thus, the study results indicate that the most effective, sustainable, and implementable plan to address the critical near-term ecosystem restoration needs in the state of Louisiana is the Tentatively Selected Plan.

Multiple diversions of Mississippi River water and sediment in Subprovinces 1 and 2, as well as the improved management of Atchafalaya River water in Subprovince 3 would provide significant human and natural ecosystem improvements, connectivity, and material exchange. Salinity regimes would be similar to the future without-project conditions, except there would be localized freshening in the following areas: Lake Borgne, the northern part of Breton Sound, Caminada Bay and the nearby headland areas, and the upper reaches of the Terrebonne and Timbalier Bays and marshes directly north of these bays.

Geomorphic structure restoration features of the TSP are directed at the restoration and stabilization of about 32 miles of barrier shorelines, headlands, and islands. Restoration of these features would require about 61,100,000 cy of sands that would likely be removed from offshore sand resource sites such as Ship Shoal and the Barataria Basin offshore sites. There would be temporary adverse impacts on benthos. Disturbance of large areas of gulf bottoms could change wave and littoral drift dynamics.

About 328,000 acres of Louisiana's marshes and swamps could be lost by 2050. The TSP would increase the acreage of all wetland habitats compared to future without-project conditions. However, over the 50-year project life, a net decrease in total wetland vegetative habitats from today's acreage is predicted to occur. In the Deltaic Plain, the TSP would minimally-to-significantly increase fresh and intermediate marsh and swamp wetland forest. It would slightly increase brackish and saline marsh. The TSP would increase barrier shoreline vegetation in Subprovinces 2 and 3. There could be an increase in all marsh types, depending on the location of the beneficial use sites. Diversions and restored barrier islands and shorelines restoration features would generally have positive synergistic effects on vegetated wetlands.

Louisiana's coastal wetlands would continue suffering extensive land loss in the future without-project conditions thereby decreasing the quantity and quality of habitats for amphibians, reptiles, mammals, and birds. There would be less stopover habitat for neotropical migratory birds. Endangered piping plover critical habitat would continue to be lost. The TSP would benefit wildlife that prefers fresher conditions (most game mammals, furbearers, reptiles and amphibians). Wintering habitat for waterfowl would be created/protected. The TSP would especially benefit migratory avian species because important stopover habitat for neotropical migrant birds would be protected. Habitat for threatened and endangered species, especially critical piping plover habitat, would also be increased. Diversions and restored barrier islands and shorelines restoration features would generally have positive synergistic effects for wildlife resources.

The LCA study area supports one of the most productive fisheries in the Nation. Fishery resources are expected to decline in the future without-project conditions as open water replaces wetland habitat and the extent of marsh-water interface begins to decrease. The multiple diversions in the TSP would have the potential to significantly freshen large areas within, and possibly an entire basin. Less fresh water tolerant species, such as brown shrimp and spotted seatrout may be displaced from areas near diversions or entire hydrologic basins. The extent of this impact is dependent on the diversion location, size and operation. Species such as Gulf menhaden, blue crab, white shrimp and red drum would likely benefit from diversions as would freshwater fishery species. With barrier island and shoreline restoration, adverse impacts to

fisheries would be significantly less. All of these restoration features opportunities would have an overall benefit to fisheries compared to the future without-project conditions. Although significant negative impacts are foreseeable within the influence areas of diversions and sediment placement, localized benefits to oysters may be achieved, as estuarine conditions are created in areas previously too saline to support oyster production. Oyster surveys and modeling where appropriate should be conducted to determine the spatial, temporal, and cumulative impacts to private and public oyster resources in the affected environment.

There would be continued loss and degradation of essential fish habitat (EFH) as well as the ability of the LCA study area to support Federally managed species in the future without-project conditions. The diversions in the TSP would preserve some highly productive categories of EFH that would be lost in the future without-project conditions. Restoration of barrier islands and shorelines would also preserve some highly productive forms of EFH; however, this preservation is not expected to be sustainable.

Continued coastal land loss and deterioration under future without-project conditions would also adversely impact threatened and endangered species that utilize the study area. The piping plover, brown pelican, and sea turtles would be the most impacted. The diversions from the TSP would have little impacts on these species. In contrast, barrier island and shoreline restoration features of the TSP would significantly enhance and create piping plover critical habitat. Sea turtles beach habitat would also benefit. Diversions and barrier system restoration features would generally have positive synergistic impacts for threatened and endangered species.

In the future without-project, should the trend of increased precipitation and climate warming continue, there would be increased runoff which may affect the total volume of fresh water in each subprovince. Overall flow in rivers and channels would remain above long-term averages, which would maintain an increased sediment load. Increased urbanization and construction could also increase runoff and sedimentation. The diversions features of the TSP would cause an increase in the volume of water and sediment entering each diversion receiving area, which may result in changes in water levels. Barrier island and shoreline restoration features of the TSP would have minimal impacts on water levels; however, construction of restoration features may relocate sediment depocenters. Diversions and barrier system restoration features would generally have positive synergistic impacts on water and sediment flows.

Most fresh surface water supplies would be from the Mississippi and Atchafalaya Rivers and their tributaries in the future. However, salinities could increase in Bayou Lafourche, which would mean users would have to treat water for salinity or find new freshwater sources in the future without-project. Diversion features of the TSP could negatively impact freshwater supplies to users downstream of medium diversions. It would increase flows into receiving areas of Subprovinces 1 and 2, Bayou Lafourche and the Terrebonne marshes, which would increase freshwater supplies to these users. Barrier island and shoreline restoration features would have negligible impacts on water supplies.

The LCA study area, in the future without-project, would still be affected by other activities that would have both beneficial and detrimental effects on water quality. Diversion features of the TSP would increase sediments in the coastal zone with accompanying minor increases in trace

metals and also increase agrochemicals. Nutrient enrichment could possibly lead to increased algal blooms. Barrier island and shoreline features of the TSP would have negligible effects on water quality.

Gulf hypoxia would continue, in the future without-project, to present the problems it does today. Diversion features of the TSP would result in a relatively small reduction in nutrients discharged into the northern gulf from the Mississippi River. Such a reduction would have a minor positive effect on hypoxia. Barrier island and shoreline restoration features of the TSP would have no impact on hypoxia.

In the future without-project conditions, historic and cultural resources in the study area would continue to be impacted by the same forces impacting them today. A cultural resources survey would need to be done on a project-by-project basis for each restoration feature of TSP.

As the existing wetlands convert to open water in the future without-project conditions, recreation opportunities would decline accordingly. Another major impact under without-project conditions could be the loss of facilities and infrastructure that support or are supported by recreational activities. Diversion features of the TSP would result in an increase in freshwater recreation activities and a displacement and decrease in saltwater activities in areas of freshwater reintroduction. There would be an overall positive effect on most wildlife dependent recreation. Reduction of land loss and land building may protect valuable infrastructure that supports certain recreation activities. Barrier island and shoreline restoration features of the TSP would have long-term positive benefits to saltwater recreation activities. Diversions and barrier system restoration features would generally have positive synergistic impacts on recreation opportunities.

Populations in coastal communities are expected to shift inland in the future without-project conditions. With the loss of current wetlands that provide storm surge protection it is likely that coastal infrastructure would suffer increased damages. Slow growth in employment is also expected to occur. Economic opportunities related to wetland resources would be adversely affected as these resources are depleted. With the TSP the inland population shift would be slower. Subsistence fishermen would potentially have to relocate to follow fisheries as salinities change. Diversion features of the TSP would also reduce the necessity for relocation, repair or replacement of infrastructure. Coastal jobs, property and population would probably be better protected than if nothing were done. Construction of the barrier island and shoreline features of the TSP would not require fishermen to relocate. Diversions and barrier system restoration features would have positive synergistic impacts on populations.

The seafood industry would likely suffer significant losses in employment in the future without-project conditions as shrimp, oysters and other valuable species decline. Diversion restoration features of the TSP would cause changes in fishing patterns, including fishery relocations and species harvested. Whereas, the barrier island and shoreline restoration features of the TSP would not cause fishery relocations.

Saltwater intrusion would continue in the future without-project conditions, except in areas where existing freshwater diversions are able to reverse that trend. Production from oyster leases

would decline gradually as areas of suitable salinity move inland and overlap with areas closed due to fecal coliform. The TSP includes diversions of a combined capacity that could potentially result in the loss of production on a significant percentage of the total leased acreage in Louisiana. It is unknown whether increased harvest from other areas could offset this loss. The barrier island and shoreline restoration features of the TSP would have minimal, localized impacts in areas where construction occurs. Diversions and barrier system restoration features of the TSP would generally have synergistic impacts (probably both negative and positive) on oyster leases, the extent of which is difficult to predict at this time.

Onshore oil and gas facilities and pipelines are generally not designed to accept wind and wave forces that could be experienced in the future without-project conditions. The owners would be faced with the decision to protect these facilities or curtail production. If any of the supply bases that service the offshore industry were impacted as a result of future erosion, the operational cost of offshore production could increase. Impacts to the price of crude oil or natural gas could ripple through the National economy. Diversion features of the TSP would provide some protection to these assets, potentially avoid the cost of relocation, and protect jobs. Barrier island and shoreline protection features of the TSP would provide an increased level of protection to the Loop Facility by restoration of some of the Caminada-Moreau Headland. Diversions and barrier system restoration features would have positive synergistic impacts on oil, gas, and pipelines.

All Louisiana's major ports and waterways are projected to have positive annual growth over the next 50 years. The TSP would repair and improve the GIWW, which would have positive impacts to navigation. If the final MRGO restoration features in the TSP were to include a closure or restriction, there would be direct negative impacts to navigation traffic.

Most hurricane protection levees would be at greater risk in the future without-project conditions, than they are at present. The diversion restoration features of the TSP would help preserve and rebuild some of the marsh that reduces storm surge thereby providing some protection to hurricane protection levees. Restoration of barrier systems also would help reduce storm surge thereby providing some protection to levees. Together, diversions and barrier system restoration features would have positive synergistic impacts on hurricane protection levees

Impacts to agriculture and forestry in the future without-project conditions would be negative: continued saltwater intrusion, continued coastal erosion, and increased damages from storms. Diversions features of the TSP would benefit agriculture and forestry by reducing saltwater intrusion into bayous and canals. Barrier system restoration features of the TSP would indirectly offer some protection to agricultural lands. Together, diversions and barrier system restoration features would have positive synergistic impacts on agriculture and forestry resources.

In addition, the TSP successfully meets the USACE Environmental Operating Principles.